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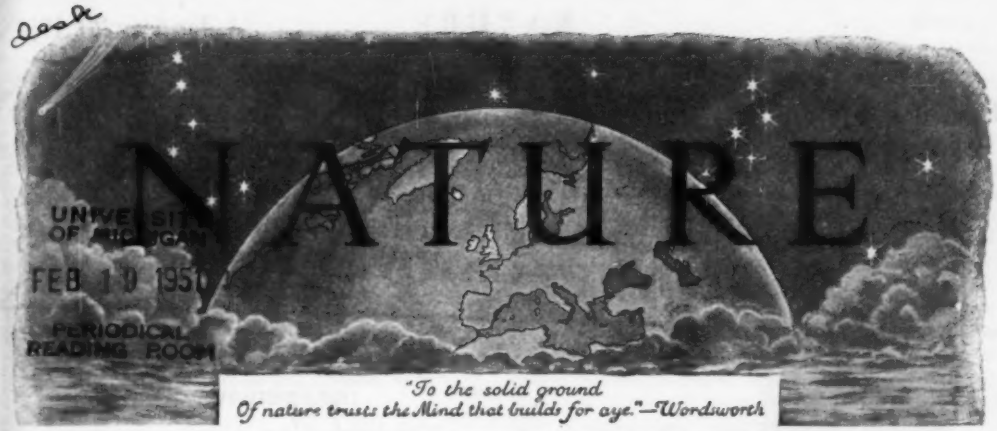

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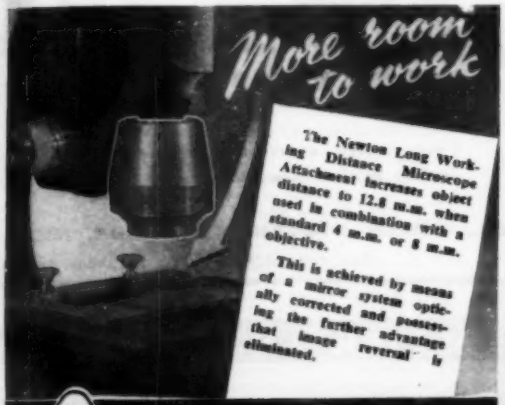
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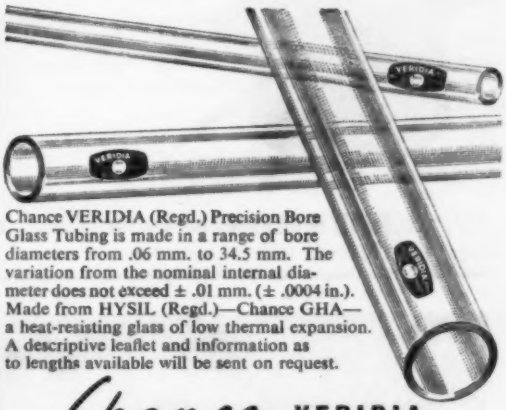

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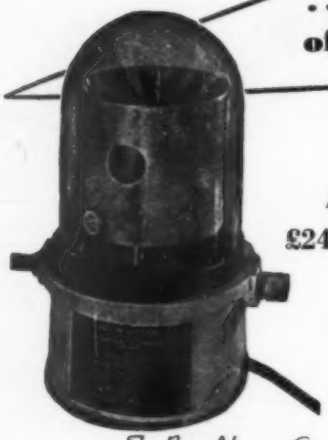

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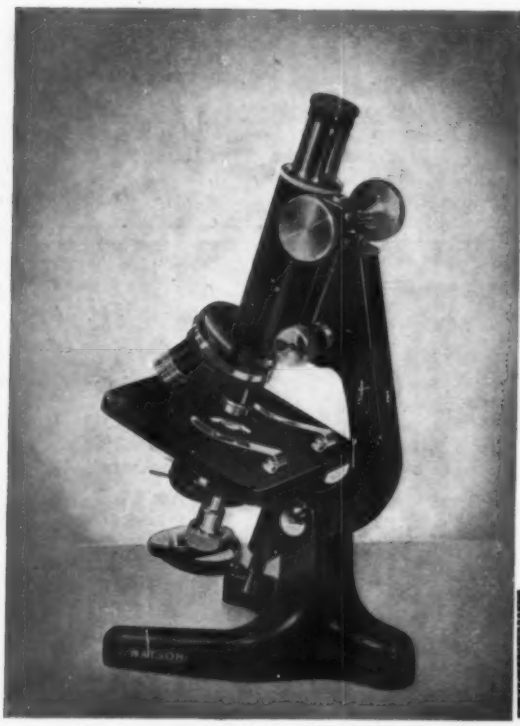

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TECHNICAL AND TECHNOLOGICAL EDUCATION

IT is fortunate that the report on "The Place of Technology in the Universities" issued by the Association of University Teachers*, and the *Planning* broadsheet on "Technological Education" prepared by Political and Economic Planning (16 Queen Anne's Gate, S.W.1), should have appeared almost simultaneously with that on higher technological education in Great Britain issued by the National Advisory Council on Education for Industry and Commerce (see *Nature*, December 23, p. 1043). Both are well fitted to remove some of the misconceptions and confusion apparent in the Advisory Council's report; and although the report of the Association of University Teachers has a bias, perhaps natural, in favour of the expansion of technology within the universities, and tends to overlook both the advantages of a new type of institution and the difficulties of administration of technological research to which Prof. A. R. J. P. Ubbelohde in particular has referred, it is nevertheless on the whole admirably balanced. Unlike some other recent reports, it recognizes clearly that industry requires two distinct types of man—the technologist and the technician—who have different functions and need different types of education.

The production of good technicians is, or should be, in the view of the Association of University Teachers, the chief function of the technical colleges. The Association does not maintain that this is the sole function of such colleges; but it urges that this is their natural function, upon which they should concentrate their energies. In the view of the Association, by the proper expansion and development of the technical colleges, especially the numerous small ones, really first-class technicians could be produced in the numbers that are required. Even if this judgment is too optimistic, it might well be added that any proposal which would divert the technical colleges from this function of training technicians must, at this present juncture, make it plain where the training of technicians is to be conducted.

There is in this report no disparagement of the technician or of the technical college, but a keen appreciation of a distinction between the functions of the technician and technologist which has often been lacking in discussions on technological education. In discussing next the training of the technologist, the Association of University Teachers correctly deals first with the question of numbers. It suggests that the present total of 11,000 students of technology in Great Britain can be very considerably augmented without seriously affecting the balance of studies in the universities of the country. No estimate is given, however, of the optimum number of technologists; and its conclusion that, provided funds are forthcoming, there is no obstacle to the expansion of university faculties of technology and the provision of new departments to the extent necessary to secure the desired output of men, may be open to

* Reprinted from the *Universities Review*, **23**, No. 1 (September 1950). 1*s*.

much the same criticism as the conclusion that the production of technologists, who are to be leaders as well as experts, is the business of those university faculties of technology. Both need to be qualified: one by the reservation in regard to the administration of higher technological studies and research, which Prof. Ubbelohde has pressed, and the other by the recognition that other institutions, outside the university system proper, may also make an important contribution.

The Association, in fact, in presenting with admirable lucidity the arguments for the study of technology within the university system of Great Britain, has tended to overstress the advantage, with the present limited resources, of expanding existing departments, rather than building and equipping completely new institutions, and to overlook the advantage which the whole field of higher technological education might derive from experimenting with new types of technological institution of university rank. The Association lays welcome stress on the importance of technological research, at least so far as it involves fundamental research into basic principles, being conducted by the university departments of technological subjects; but it fails to recognize the practical difficulties which are sometimes involved. It recommends closer collaboration between universities and research associations and industrial laboratories, so as to promote interchange of ideas and facilities in fundamental research, and to enable work of the development type, which, though essential, is not of any particular intellectual interest or educational value, to be handed over to industry. Here again, experiment with new institutions, such as the proposed technological universities, might well prove of far greater value than the Association suggests.

The Association also recognizes the importance of the staffing question and recommends that university technological departments should be so organized as to encourage transfer from industry, and that research fellowships should be created with the view of enabling suitable men with industrial experience to spend a number of years in academic research. Here it stresses, too, the value of closer collaboration between the technology departments of the universities and the research associations. Moreover, in regard to research, it recognizes that while contact with industry may usefully influence research policy in the technological departments by indicating the directions in which immediate advance is most to be desired, it is essential that there should be no interference with the freedom of the university research worker to develop his chosen line in his own way.

That danger happily is remote; nor is there at present any indication that even in the field of technology the universities are likely to be diverted from the unhampered quest of knowledge by Ministerial demands for tangible results from research. That is the real danger which the dependence of the universities upon Treasury support might involve; and, while there is no sign that the present Government or its predecessors have ever attempted to put pressure on the universities, the vigilance of the University Grants Committee and of the Association of University Teachers should assure the universities of strong support in resisting any attempt in the field of technology or elsewhere to weaken their independence.

The great merit of the *Planning* broadsheet on technological education is that it demonstrates the wide measure of agreement that has already been reached. Its balanced review of the provision to be made for the education of technologists up to graduate and postgraduate standards, the kind of education to be given, and where and under what type of administration, and what we could learn from other countries that would assist in building up a new and better system, are of much value. Whatever the shortcomings of the British system, its flexibility and its opportunities for development in different directions are advantages which no one wishes to discard. The comparison with systems abroad is perhaps the chief contribution of the broadsheet to the discussion, though it also presents a concise picture of the present system in Britain, as well as a pointer to all the more important reports and discussions of the past six years.

Within the area of agreement, there is still room for argument on certain points. The broadsheet mentions the nature of the provision to be made for postgraduate as distinct from undergraduate training; the length of the various courses (how far, and for what type of student, they should include fundamental science, the humanities and the social sciences); and whether or not part-time study should be included. It does not, however, refer to the question whether the training of technicians and technologists can be conducted within the same institution, and it is rather strange to find that *Planning* regards the establishment by the Minister of Education of five national colleges, each specializing in a branch of technology, as a contribution to technological education rather than technical education.

The main point of disagreement, however, is on whether development should be confined entirely to the kind of institution already to be found in Great Britain, or whether in addition a new type, such as exists in the United States and on the Continent, should be established or developed. Although Lord Eustace Percy, in addressing recently the Institute of Physics, opposed very strongly the proposal to establish a technological university, there seems to be growing support for the idea of starting at least one such institution. Lord Eustace Percy's speech drew a strong reply from Lord Cherwell, who pressed the economic argument against developing a number of comparatively small university departments of technology, all requiring expensive equipment; and, as *Planning* points out, it is difficult to see how an experiment on these lines would prejudice the development of the universities or the technical colleges. A PEP Group is preparing a survey of British universities and is keeping an open mind on the subject, pending a detailed investigation of the actual and potential provision in existing institutions. The present broadsheet invites the views of readers

or subscribers to Political and Economic Planning, and it would seem that response should assist in the preparation of a survey of real value. Nor is it likely that in such a survey the advantage of such experiment to university education as a whole, and to technological education in particular, will fail to receive due weight.

PRINCE PETER KROPOTKIN

The Anarchist Prince

A Biographical Study of Peter Kropotkin. By George Woodcock and Ivan Avakumović. Pp. 463+7 plates. (London and New York: T. V. Boardman and Co., Ltd., 1950.) 21*s.* net.

TO men of science Prince Peter Kropotkin is probably best known by his book called "Mutual Aid". To those who share his views on anarchy, his biological contribution to evolutionary theory is considered to be but one of the many issues in the life of this remarkable man who dedicated himself to the spread of libertarian ideals through peaceful revolution.

Briefly, though not chronologically, Kropotkin's adult life was devoted to four main activities. First, there are his contributions to pure science; secondly, his astonishing predictions in the realm of sociology; thirdly, his unceasing witness to the theory and practice of anarchism; and, finally, his unquenchable faith in, and work for, humanity.

Kropotkin's contributions to pure science were mainly in geography and biology. These were chiefly made before he was thirty years of age and arose out of his voyages of exploration in Siberia and Manchuria. Apart from the new territories and new routes which he opened up in these countries and which were later utilized by the planners of the Trans-Manchurian Railway, Kropotkin showed that Humboldt's theory about the nature of the mountains of Asia were not consistent with observation. Instead of a network of ranges, some running due north and due south and others along the east to west parallels, as Humboldt believed, Kropotkin showed that Asia had been built up around an ancient primary massif which was itself the remnant of a still older circumpolar continent. Although the actual structure of the Asian continent has since been shown to be more complicated than Kropotkin first imagined, his general theory remains undisputed and is supported by many modern geographers. Besides this work on the orography of Asia, Kropotkin also added a great deal to knowledge of glaciation and desiccation. One interesting result of his incursions into Arctic geography was that, although unable to secure the necessary finance to undertake the expedition himself, two years before the discovery of Franz Joseph Land by Payer and Weyprecht, Kropotkin had indicated the route along which the expedition could sail and his belief in the existence of an unknown land.

The seeds of Kropotkin's theory of mutual aid were also sown on his Asian travels. During this period Kropotkin had looked in vain for evidence of that intense struggle for existence between members of the same species which Darwin had postulated as the principal factor in natural selection; he saw instead a high development of co-operation. Later, while imprisoned in France, Kropotkin was much impressed by Kessler's general belief in the importance of co-operation as a factor in evolution. Reacting strongly to Huxley's statements about the ferocity of the struggle for existence, Kropotkin suggested that the observations of practical zoologists showed a prevalence of co-operation, at least within each species, and, moreover, that social species had a greater tendency to survival than solitary kinds. Although Kropotkin accepted the fact that the struggle for existence is of metaphorical evolutionary significance in the form of struggle against adverse circumstances, he insisted that as competition within the species it is present only in exceptional circumstances and is then more injurious than advantageous, since it dissipates the advantages gained by sociability. Kropotkin also applied his ideas to primitive man, among whom, he said, there is a tendency to live not in family groups, but in tribal aggregations, where law as such is unknown and is replaced by a complex system of customs ensuring co-operation and mutual aid.

Yet, although he made important contributions to pure science, Kropotkin's temperament was such that he could never remain in a social vacuum. His frequent journeyings to Europe and his travels in America provided him with ample opportunities of observing conditions in industry and agriculture, and led to considerable speculations about the way science could be applied for the well-being of mankind. His first major sociological book, "Fields, Factories and Workshops", appeared in 1896, and set out a number of ideas on industrial organization and cultivation of the land which are still considered to be in keeping with contemporary thought. This was followed by articles in a variety of journals, including *Nature*, which are of more than historical significance. (Readers of *Nature* may be interested to know that a former assistant editor, James (afterwards Sir) Scott Keltie, was one of the first to greet Kropotkin on his arrival in Britain in 1876, and at once invited him to write regular notes of scientific events which were recorded in the foreign Press. For some time Kropotkin wrote under an assumed name; but felt forced to reveal his identity when Keltie invited him to review his own books on the glacial period and the orography of Asia. Kropotkin's link with *Nature* remained unbroken until his return to Russia in 1917.)

If Kropotkin had been asked how he wished to be remembered, however, there is little doubt that it would not have been for his contributions to geography, biology or sociology. It would have been as a prophet of the creed of anarchism which, according to Kropotkin, if accepted by all men would lead to the fullest freedom for all by the disappearance of the State with its system of authority and coercion which maintains and perpetuates property relationships. In a system based on individual and local responsibilities, human brotherhood would lead to the elimination of all class distinctions and, with them, war. Most of Kropotkin's thinking life was spent in propounding this philosophy, and, in their book, George Woodcock and Ivan Avakumouić record the surprising flow of intermingling revolutionary currents which haunted Europe in the latter part of the past century and the early part of this. It is a tribute to the biographers that they have not only written a biography which faithfully records the life of a famous man, but also illuminates the social history of his time.

While there is little support for Kropotkin's anarchical ideas to-day—although *Freedom*, which

was one of the many journals founded by Kropotkin, still appears as the official organ of anarchists—there can be few who would not acknowledge his service to humanity. The Doukhobor colony in British Columbia, for example, which to-day flourishes as an autonomous community, owes its escape from Tsarist persecution and its free existence jointly to Tolstoy and Kropotkin. Mahatma Gandhi, said to be Tolstoy's greatest disciple, was an enthusiastic reader of Kropotkin's unceasing flow of articles and based his idea of a society of village communes in India on Kropotkin's theories. In the twilight of his long life after triumphantly returning to Russia in 1917, following forty years of life in exile, Kropotkin tasted the bitterness of the Revolution which he had helped to promote. Yet, in his misery, his faith in man and progress was undimmed and led to the production of his well-known book on ethics in his seventy-seventh year. Of this book Herbert Read has justly said: "No better history of ethics has ever been written". Nor has a better biography than this been written of one who served his age so selflessly and mistakenly and who was described by Oscar Wilde "as one of the two men he had met who lived perfectly fulfilled lives".

T. H. Hawkins

GENETICS REVISED

Principles of Genetics

By Prof. Edmund W. Sinnott, Prof. L. C. Dunn and Prof. Th. Dobzhansky. (McGraw-Hill Publications in the Botanical Sciences.) Fourth edition. Pp. xiv+505. (London: McGraw-Hill Publishing Co., Ltd., 1950.) 42*s.* 6*d.*

THE writing of a text-book of genetics presents a special difficulty. It is that the subject has advanced by a series of explosions which might have been expected to shatter whatever system or order had preceded them. The discovery of *Drosophila* by Morgan and of the X-ray tube by Muller each put the subject on a new technical and theoretical basis; and after so many years we have still not exhausted the possibilities of studying either Morgan's recombination at meiosis or Muller's mutation at mitosis. Yet since these things happened we have had to absorb new systems of chromosome mechanics and chemistry, of micro-organismal genetics and cytoplasmic particles and of evolutionary and taxonomic analysis.

All these explosions have burst on us since the first edition of Sinnott and Dunn's "Principles of Genetics". It would not be surprising, therefore, if the fourth edition (although strengthened by the collaboration of Prof. Dobzhansky) were to show some signs of dislocation; perhaps, indeed, it does. But the absence of stability in detail merely emphasizes the stability in principle. It is more refreshing than otherwise, and among much that has been rewritten, all students of natural variation and the origin of species will be glad to see their chromosome foundations and adaptive properties so well described in the new edition.

There is, however, a second difficulty in writing about genetics, namely, that all those who have so far attempted to lay the subject before us have had some training in pre-genetic biology. It is only in the twenty-five years since this book first appeared that the position of the new discipline has become clear. Genetics, as we now see, is itself the framework of biology. It is simply the demonstration of the primary determinism of living organisms.

How is a writer on genetics to explain this position to students who, like himself, have been trained in what passes for biology in the formal pre-genetic or non-genetic curriculum? The present work, having grown through many editions, cannot attempt this task. It does something different, however, which no one else has succeeded in doing so well. It patiently lays before the student the experimental foundations of the subject. It does so in a simple form with all the necessary technical and historical background, and it provides a wealth of pictorial illustration.

Every book on genetics at the present time is bound to be an experiment in trying out one or other of the hundred different ways of presenting the subject. The successful experiment will be the basis of future methods of teaching and also perhaps of research. The present work is not likely to be important in this direction. Rather it is to be looked upon as a step in the transition from the old biology to the new. It is a necessary step in which the new genetic methods of inquiry and their results are introduced gently to an audience which does not yet realize that the old foundations of botany, zoology and microbiology, are being undermined, and that the classical notions of evolution, species, individual, sexual reproduction, organism, disease and life are disintegrating under their eyes.

The reprinting as an appendix of the Royal Horticultural Society's translation of Mendel's original paper seems now to be particularly valuable. Those who read it again (especially the concluding remarks) will realize that Mendel's work was not wholly rediscovered in 1900 and will profit by the realization. They will also learn something of the process of discovery itself.

C. D. D.

CLASSICAL INVESTIGATIONS OF THE PLASTIC PROPERTIES OF CRYSTALS

Plasticity of Crystals

With Special Reference to Metals. By Dr. E. Schmid and Dr. W. Boas. A translation from the German by F. A. Hughes and Co., Ltd., of 'Kristallplastizität mit besonderer Berücksichtigung der Metalle'. Pp. xvi+353. (London: F. A. Hughes and Co., Ltd., 1950.) n.p.

IT is not surprising that a translation has been made of this well-established classic. What is surprising, at first thought, is why a translation has appeared now, and only now, some fifteen years after the original. The answer to this question reflects, in addition, of course, on the exceptional standard of the work, upon the way in which this branch of science is claiming the attention of an increasingly large audience, an audience of wider interests than the specialists who acclaimed the original publication.

Intensive research into the physics of the plasticity of crystals began around 1920 when the developments of X-ray crystal analysis and of methods for growing single crystals prepared the way for a systematic attack. During the following ten years or so a wide field was opened up. The crystallographic aspects of slipping, twinning and fracture were thoroughly studied, particularly in

metallic and ionic crystals. Exact geometrical laws governing the kinematics of slipping and twinning were formulated, the resolved shear-stress law of slip was discovered, and much was learned about the processes of strain hardening, alloy hardening, thermal softening, recrystallization and the formation of textures. The main task that Dr. E. Schmid and Dr. W. Boas set themselves was to tell the story of these discoveries. They did it superbly. For this reason, and also because the story forms a more or less self-contained chapter in the science of plasticity, these parts of their book are as fresh and useful as when they were first written.

Since that time the subject has changed in two ways. First, its technological value has become more widely recognized. Practising metallurgists have realized that the solution of certain problems—for example, the working of hexagonal metals, or the production of transformer sheets with magnetically soft textures—depends upon a detailed knowledge of the crystallographic laws of plastic deformation. It is noteworthy that the translation under review was sponsored by an industrial firm that specializes in magnesium, a metal which is particularly difficult to work because of the manner in which it deforms.

Secondly, academic interest has turned towards the task of building up a theory of plasticity in terms of atomic structure. In 1935 the theory was still convalescing after the shock of the great discrepancy between the theoretical and observed strengths of solids. Admittedly the idea of dislocations had already been thought of; but it was too early for the full impact of this to be felt. The theory of plasticity has now advanced almost beyond recognition, partly because of new knowledge that has come from refined experimental techniques, and particularly because of the new life that the idea of dislocations has brought into the theoretical work.

Because of these developments the last two chapters of the book have become rather dated and their interest is now largely historical. Is it possible to persuade Dr. Schmid and Dr. Boas to prepare a second edition, to tell this second part of the story in the same masterly way as the first one? Perhaps the success with which this very good translation, by Mr. L. H. Tripp, must surely meet, will encourage them to do so.

A. H. COTTRELL

ORGANIC CHLORINE COMPOUNDS

The Preparation, Properties, Chemical Behavior and Identification of Organic Chlorine Compounds

Tables of Data on Selected Compounds of Order III. By Prof. Ernest Hamlin Huntress. Pp. xxv+1443. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1948.) £8 5*s*. 0*d*. net

SUCH strides have been made, both academically and industrially, since Mulliken's volumes on the identification of pure organic compounds appeared that the task of modernizing them is no light undertaking, both by way of deciding what to include and what to omit. The first volume of this revision appeared in 1941 and covered compounds of order I, that is, compounds of carbon and hydrogen with or without oxygen. With the present volume, which deals with compounds of order III, that is, compounds of carbon and chlorine with or without hydrogen and/or oxygen, many changes have been introduced; even the publisher's well-known reddish-brown binding has given place to one strongly suggesting the colour of a positive Beilstein halogen test. Compounds are not arranged, as formerly, in chemical families. The classification is simply: solids, in order of melting point; liquids for which boiling points at ordinary pressure are reported, in order of that boiling point; and liquids with boiling points reported only at reduced pressure, in sequence of their empirical formulæ. The second group is subdivided into sections according to whether the density at 20° C. is greater or less than 1·15.

The author has not attempted on this occasion to select the best values for physical properties, but has given the full range culled from the literature; where some appeared to be doubtful, this opinion has been indicated. The most important change, however, is in the treatment of the individual entries; the aspect of identification, which was the main purpose of the earlier volume, is fully retained, but the scope has been widely increased to include also methods of preparation (in outline), general chemical behaviour and uses. In consequence, the number of references to the literature has been greatly increased, for example, to more than six hundred for chloroacetic acid; and patent references are also included in moderation and with reserve. The information given is based on a careful search of the literature up to 1945, supplemented to some extent by a selection from 1946 and 1947; but there is no claim that every iota of information has been detailed. One rather novel feature is the inclusion of negative information, that is, where a particular reaction or derivative has not been reported, though the word "unreported" really implies not traceable from index sources.

In all, 1,320 compounds of order III are given individual treatment, of which more than one-quarter are so relatively new as not to be mentioned in the fourth edition of Beilstein; for the others, Beilstein references are included. Of course, with the derivatives described for identification purposes and others mentioned in connexion with chemical behaviour, the compounds described are very much greater in number and, of necessity, branch out in other 'orders'. The space allocated to an individual varies greatly, ranging from a few lines to several pages. This 'order' includes many chemicals of commercial importance, for example, solvents, insecticides, plant-growth regulators, medicinal compounds and intermediates for a variety of purposes; these obviously demand more detailed treatment than compounds which are included because they are relatively simple members of their respective families.

A special feature is made of indexing. Apart from the conventional alphabetical name-index, which includes many of the possible alternative titles, there are indexes based on empirical formulæ, on percentage chlorine content, on molecular weight and on chemical type; the last forms a link with the system adopted for Volume 1. It would have been a remarkable achievement had no errors slipped through in a work of this size and of such detail, but the few which have been detected are not worthy of mention here. The combination of the identification aspect with that of chemical behaviour and uses makes this book a contribution of great worth to chemical literature, a value which will be enhanced when the companion volumes appear.

THE THEORY OF MAGNETIC STORMS AND AURORAS

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Of the many theories of magnetic storms advanced during the past fifty years, there survives only that of Chapman and Ferraro[1]. This theory postulates a *neutral* ionized stream of particles, expelled from the sun with velocities (u) of order 10^9 cm. per second, in accordance with the well-known fact that particles emitted during solar catastrophes appear to take about a day to reach the earth's neighbourhood. Chapman and Ferraro find that the surface of this stream, which is a good conductor, will be retarded by the earth's magnetic field (H) at a distance of several earth radii, and that a region around the earth will be 'forbidden' to the solar stream. In this space the earth's field will be slightly compressed, thus producing the increase in H which is generally characteristic of the first phase of magnetic storms of sudden commencement. The evidence is strong that after some hours a westward-flowing current is set up in a ring lying in and near the (geomagnetic) equatorial plane, at a distance of several earth radii. Chapman and Ferraro were unable to account satisfactorily for the formation of this ring current, but made a careful examination of the (quasi-) steady state of this ring, once in existence. They made no attempt to account for the solar diurnal (S_D) magnetic variations, either in polar or non-polar regions, or for the intensified current systems in the auroral zone; neither did they seek to explain the apparent penetration of solar corpuscles of such low energies into our atmosphere to heights as low as 90–100 km.

The strength of the Chapman–Ferraro theory lies in the extreme care with which each necessarily occurring process has been analysed, often by several different approaches. If it were possible to continue further by such methods, there is little doubt that a sound quantitative explanation of the observed phenomena could eventually be reached. Unfortunately this is not likely to happen, because of the very serious analytical difficulties certain to be encountered. In their most recent attempts[2], Chapman and Ferraro have been forced to detailed consideration of the motions of individual particles, since in certain circumstances particles of opposite sign become separated.

In an attempt to break this deadlock, I have gone back to some general macroscopic considerations involved in the theories of hydrodynamics and electrodynamics. It is increasingly clear (cf. G. K. Batchelor[3]) that a tenuous ionized gas, moving in a magnetic field, presents formal analogies with well-investigated hydrodynamical problems; the hydrostatic pressures of the latter are replaced by the pressures due to the interaction of induced electric currents with the magnetic field.

The steady state of flow of an ionized stream past a magnetic dipole is akin to that of stream-line flow of incompressible fluid around a submerged obstacle; it is probable that the fluid will completely enclose a hollow space surrounding the dipole. (No other steady state seems possible, without a disturbed motion of the fluid at an infinite distance from the earth. Moreover, if there remained a gap behind the earth, the stream would exert on the front of the hollow an uncompensated pressure which would necessarily manifest itself in the S_D-current system; such a system appears only in the initial phase of a storm.) A necessary consequence of the curved flow around this hollow space is that the stream carries a current flowing westwards around the earth in the equatorial plane; this current is necessary to balance, by interaction with H, the centrifugal forces involved.

An estimate of the dimensions of the hollow may be obtained by the simple but justifiable approximation of equating the pressure exerted by the solar stream (that is, the energy density of the stream $\frac{1}{2} N m u^2$, N being the number density and m the mean mass of the particles) to the pressure exerted by the lines of magnetic force ($H^2/8\pi$). In the geomagnetic equatorial plane $H = 0{\cdot}33/z^3$, z being the distance from the centre of the earth in units of earth radii. Thus we have

$$z = (0{\cdot}2/64\pi^2\, N\, m\, u^2)^{1/6}, \qquad (1)$$

and if we assume the solar stream to consist mainly of ionized hydrogen, then, since u is about 10^8 cm./sec.,

$$z = 8{\cdot}8\ (1/N)^{1/6}. \qquad (2)$$

Thus the size of the hollow varies little over wide ranges of N or m.

Another estimate of the size of the hollow may be obtained (cf. Chapman and Ferraro) by considering the magnitude of the rise in H (about 25 γ) in the initial phase, when the oncoming stream compresses the earth's field. The surface currents in the approaching sheet may be replaced by an image dipole, which will be distant $2z$ from the earth when the sheet is brought to rest. Thus

$$0{\cdot}33/(2\,z)^3 = 25 \times 10^{-5}$$
$$\text{and } z = 5{\cdot}5.$$

Hence by (2), N is about 20 per c.c. If we consider the lines of magnetic force which touch this hollow, in the equatorial plane, and follow them back to the earth, they will intersect its surface at co-latitude θ_1, where

$$1/\sin^3\theta_1 = 5{\cdot}5, \text{ and so } \theta_1 = 25°.$$

This is nearly the co-latitude of the auroral zone; it will appear later that this consideration may be that which determines its position.

We now examine the stability of the stream moving in the equatorial plane in a curved, roughly circular, path of radius r ($= 5{\cdot}5\ a$) on the lateral inside surfaces of the hollow. It has been shown by Chapman and Ferraro that for stability a radial polarization field E is necessary. Considering ions (i) and electrons (e) separately, and taking u positive when westwards,

$$-m_i u_i^2/r = eE - eu_iH \qquad (3)$$
$$-m_e u_e^2/r = -eE + eu_eH. \qquad (4)$$

Adding,

$$m_i u_i^2 + m_e u_e^2 \doteq m_i u_i^2 = + reH(u_i - u_e). \qquad (5)$$

Thus $u_i > u_e$, though, as Chapman and Ferraro have shown, $(u_i - u_e) \ll u_i, u_e$. Hence a westward electric current is necessary, on both sides of the earth, in order to allow the stream to flow in a curved path.

The magnitude of the current will be

$$i = Ne(u_i - u_e)\,A, \qquad (6)$$

where A is the (mean) cross-section of the current-carrying 'ring'. This ring will produce a (negative) field at the earth, of magnitude ΔH, where

$$\Delta H = 2\pi i/r\,; \qquad (7)$$

so that, combining (1), (5), (6) and (7),

$$A = 2\,z^3a^3\Delta H/0{\cdot}33,$$

and, taking z as 5·5 and ΔH as 50 γ, the observed decrease in H in the main phase of an average magnetic storm, we have

$$A = 15\,a^2.$$

Chapman and Ferraro have shown that a current system of this type has considerable momentum, and, once started, will continue to flow for many days. On the present view, the current system is set up as a necessary accompaniment of the steady state of flow of the stream past and around the earth; when the stream ceases to flow (after about a day), the current system will remain, by virtue of its momentum, and may be considered (in rough approximation) to have toroidal ring form. For simplicity we assume here a circular cross-section of radius b, so that A is πb^2. It then follows that b is approximately $2a$, or about equal to the diameter of the earth.

It has been mentioned that a radial polarization field E (of order of magnitude uH or 10^5 E.M.U.) is necessary for the stability of the ring; also that the lines of force from the ring (lines of very great electrical conductivity) cut the earth's atmosphere in the auroral zone. This suggests that part of the polarization field will be transferred to the earth's atmosphere (since, except in the immediate neighbourhood of local fields due to free electrostatic charges in the ring or zone, the lines of force must be nearly equipotentials) and will give rise to a meridional electric field across the auroral zone. If δr $(=2b)$ be the radial separation of the lines of force which touch the inner and outer surface of the ring, then from the geometry of a dipole field we have

$$\delta r = -\frac{2\,a\cos\theta_1}{\sin^2\theta_1}\,\delta\theta_1\,;$$

and taking δr as $2{\cdot}6 \times 10^9$ cm., there follows $\delta\theta_1 = 6°$, as the width of the terrestrial zone experiencing the field. This is the width of the auroral current zone, according to Chapman and Vestine[4]. It appears, therefore, that there may be good reason to associate the intense auroral and magnetic activity in the auroral zone with the fact that it, and only it, is in good electrical connexion, throughout its length and breadth, with all parts of the extra-terrestrial ring.

Chapman and Ferraro have shown that the polarization on the surfaces of the ring is unstable, charges of either sign being expelled (along the lines of force) with force comparable with (but less than) euH; this leakage is immediately made good from the body of the ring. It now appears, however, that this leakage may be more than a secondary phenomenon, as far as auroras and magnetic storms are concerned. The expellent field is of order 10^{-3} volts/cm., extending over a distance of order 10^9 cm. There is therefore little doubt that the ejected particles will possess sufficient energy to penetrate the atmosphere to the 90–100-km. levels; it is also clear that they will impinge only on the auroral zone, being guided thereto by the earth's magnetic field. In this zone they will produce in the ionosphere enhanced ionization and conductivity, particularly at the lowest levels of penetration. The energies of the incoming particles are such that luminescence (auroras) must accompany this bombardment. It seems also clear that currents will flow along meridians across the auroral zone, particularly at about 90 km., since particles of opposite sign bombard its inside and outside edges. This current system, flowing in a closed system of sheets from the ring to the zone, across the zone at about 90 km., and thence back to the ring, will produce small magnetic effect at the *surface* of the earth. It is possible, however, that these currents are intense enough to contribute to auroral phenomena.

There remains an important by-product of the meridional field across the auroral zone. Preliminary calculations show that the potential difference between the inner and outer edges of the zone is probably somewhat greater than 10^5 volts, so that the meridional field E_a is rather more than 10^{-3} volts/cm. This field, in conjunction with the nearly vertical magnetic field H_a in the auroral zone, will produce a drift motion of ions of both signs of magnitude

$$\frac{E_a}{H_a}\cdot\frac{\omega^2}{\omega^2+\nu^2},$$

where ω $(=He/m)$ is the ionic gyro-frequency, and ν the ionic collision frequency. This drift will be westerly on the sunrise, and easterly on the sunset meridians, during the first day of the storm, when material is still flowing from the sun. As this flow diminishes, and the momentum of the ring current dominates the circulation in the ring, the drift will be westerly in all parts of the zone. Now if the masses and collisional cross-sections of both types of ion (+ and −) were identical, these drifts would merely transfer ions, in the first day of a storm, from the sunlit to the dark side of the auroral zone. (As the ring current became established, and the solar stream died away, the drift would then cause a circulation of ions westward round the auroral zone.) It is highly improbable that the masses and cross-sections of both types of ions are identical, but in the present state of ionospheric theory it is not possible to assert how they differ. It is found that many observed magnetic and ionospheric phenomena can be readily explained if the positive ions drift somewhat faster (by 10–30 per cent) than the negative. In this event a Hall current, amounting to some half-million amperes, will flow round the auroral zone, in the first day of a storm, westwards on the dawn hemisphere, and eastwards on the sunset meridian. This Hall current must set up a polarization field, which tends to impede its flow, and is positive on the midnight, and negative on the noon, meridians. The potential of this field can be represented (in the auroral zone) approximately by $S_e\cos\varphi$, where φ is longitude measured from the midnight meridian. The potential distribution thus set up in the highly conducting auroral zone will give rise to an ionospheric current system in all parts of the earth. It can be shown that the eastward component of this current system in latitude θ is proportional to $\frac{1}{4}S_e\sec^2\frac{\theta}{2}\cdot\cot\frac{\theta_1}{2}\cdot\sin\varphi$ inside each (N. and S.) polar cap, and $S_e\,\mathrm{cosec}^2\,\theta\cdot\sin\theta_1\cdot\sin\varphi$ between the two auroral zones. This current system has the strength and form required to explain the main features of the S_D-field, as described by Chapman and Vestine[5].

On these views, it will be seen that the entire S_D-current system and also the S_t-system of the auroral zone flow in the ionosphere, near the 90-km. level; the world-wide S_t-system flows in an equatorial ring 5–6 earth radii distant. It is also found that the current system of bay disturbances (Birkeland's "elementary polar storms"), as described by Vestine[6], can be accounted for in the same manner as the main S_D-storm field, if they be considered as a manifestation of the process of closing the gap behind the earth. For this to happen the 'forbidden' hollow must act as a double source, transferring material from its anterior to its posterior surface. The current system necessary to effect this is similar in form to that considered above for the main S_D variation, but advanced in phase by six hours. Theoretically it should always be present, even after steady flow is established around the hollow, and the ring current has gained momentum. This appears to happen: the idealized S_D-system due to Chapman, symmetrical about the noon–midnight meridians, should be advanced in phase by about two hours, according to Vestine's more recent investigations.

One of the most puzzling features of magnetic storms is their profound effect on the heights and electron densities of the F_2-region in the ionosphere, at all latitudes. It is found that these F_2-disturbances have characteristic diurnal and storm-time morphologies, which resemble closely those of the magnetic variations. They are pronounced even at the equator, a fact difficult or even impossible to explain in terms of direct bombardment by solar particles. It is found that the above-mentioned ionospheric current systems, produced by strong equatorial east–west electric fields, and therefore necessarily associated with pronounced vertical electronic drifts, appear to explain many of the observed ionospheric phenomena. The discussion of these must be left to another communication.

This work is published by permission of the Radio Research Board of the Commonwealth Scientific and Industrial Research Organization: it owes much to critical discussions with Prof. S. Chapman.

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THE NEW SCIENCE OF RADIO ASTRONOMY*

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THE fundamental discoveries in radio astronomy were made nearly twenty years ago; but the emergence of radio techniques as a powerful force in astronomy has only occurred during the five years since the Second World War. The recent discoveries have been so remarkable that it now appears strange that the basic techniques and observations made by Appleton[1] and Skellett[2] on meteors, and by Jansky[3] on the extra-terrestrial radio emissions, lay practically dormant for so long. Even so, it seems very unlikely that radio astronomy could have developed so rapidly but for the incidence of the War, which resulted in an otherwise unattainable concentration of intelligence on the development of radio and radar. In 1945 a large amount of apparatus existed, the potential performance of which was far in excess of that used by the early investigators. Equally important was the existence of groups of physicists who had gained sufficient experience to realize the immediate possibilities, and to refine the techniques even further in the subsequent years. In the restricted compass of this article it is not possible to discuss all the contemporary aspects of these developments; but their scope and significance will be illustrated by reference to the most recent work on the extra-terrestrial radio emissions and in meteor astronomy.

Meteor Astronomy

The problem of interstellar meteors. Every day some 8,000 million meteors enter the atmosphere of the earth. Cloud, daylight and moonlight have presented such serious obstacles to the systematic visual and photographic observations of these phenomena that the ideas of their origin and significance have been very diffuse. In fact, one of the perpetual arguments in astronomy concerns the interstellar or solar system origin of the majority of these particles. This argument could have been settled at any time, given the ability to distinguish between meteors moving with heliocentric velocities of more or less than the parabolic limiting velocity of 42 km./sec. Since the orbital velocity of the earth is 30 km./sec. this corresponds to a parabolic limiting velocity in the earth's atmosphere (geocentric velocity) of 72 km./sec. for a meteor encountered in the head-on position. Owing to the transient nature of the apparition, the accurate measurement of such velocities with conventional techniques presents almost insuperable difficulties. The precise, rotating-shutter, photographic measurements of Whipple[4] with the cameras so far used have been limited to the brighter meteors, but no hyperbolic velocities have been found. On the other hand, from his rocking mirror observations during the Arizona meteor expedition, Öpik[5] claims that a large percentage of the visible meteors are moving with hyperbolic velocities. Hoffmeister[6], from a study of the distribution of meteors, also holds that an appreciable fraction of the total number is of interstellar origin. These views regarding the interstellar origin have been severely criticized by the British observers[7]. To this impasse the radio echo technique for the measurement of velocities has been applied with conspicuous success during the past few years. Two independent experiments have been made, in Canada by Millman and McKinley[8], and in Great Britain by Miss Almond, Davies and Lovell[9]. In each case the velocities of the meteors have been obtained by measuring the Fresnel zone separations in the diffraction pattern produced as the ionized meteor column forms in the high atmosphere. Millman and McKinley, using a continuous-wave technique with wide-beam aerials, have measured more than ten thousand velocities. The British workers have used a pulse technique, and by using beamed aerials have selected a much smaller group of sporadic meteors lying in planes through either the apex or antapex of the earth's way.

* The substance of this article is based on an evening discourse given on September 4, 1950, at the British Association meeting in Birmingham.

Both experiments have yielded the same unambiguous result—that no meteors of visual magnitude possess hyperbolic velocities. In the light of these results it is difficult to see how the theory of an interstellar origin for any of the meteors brighter than the sixth or seventh magnitude can be supported.

The great day-time meteor streams. The ability to make a systematic study of meteoric activity, unhampered by cloud or daylight, led quickly to a surprising discovery—the existence of intense meteor activity in the summer day-time. The general features of meteor activity during the night-time are well known from visual observations; on a clear night a single observer can see 2–10 meteors per hour, distributed sporadically. At certain times the rate is greatly enhanced and the meteors appear to diverge from a radiant point: these meteor showers arise when the earth sweeps through a concentration of debris in space. If the velocity and direction of the radiant are measured, the orbit in which the debris moves can be computed. Some twelve regularly recurring major night-time showers have been recognized, and from the somewhat meagre data available it has been generally assumed that the debris is associated with a comet. In one or two cases the relation is quite evident. The most recent and striking example is that of the passage of the earth through the orbit of the Giacobini–Zinner comet only fifteen days after the comet had passed the junction of the orbits in the early morning of October 10, 1946. In just over three hours the meteoric activity increased by 5,000 times and as quickly disappeared[10]. In 1933 a similar event occurred; but in the intervening years the comet has been far from the earth when the orbit has been crossed, and no shower has occurred. The comet was not discovered until 1900, and in this case the debris still seems to be localized near the comet. In the whole history of meteor astronomy there have been very few such events, and the more normal occurrence is for a major shower to yie'd an hourly rate of about fifty. At the present time only three of the dozen major showers yield such a rate—the Quadrantids in January (for one night), the Perseids in August (for four or five nights), and the Geminids in December (for four or five nights). These are the yardsticks by which the intense summer day-time activity has to be judged.

The radio echo survey carried through during the summer of 1947 indicated that these regular night-time events were completely dwarfed by the unprecedented intensity of a series of streams which commenced in May and continued until the end of July[11]. The radiants are only above the horizon during the day-time, and hence the streams cannot be seen visually. Subsequent observations[12] showed that these phenomena were recurrent; but although the main radiant positions were determined, little fundamental cosmological information has been available about them until the summer of 1950, when successful determinations of velocity were also made. The activity appears to be due to at least four recurrent streams with a number of non-recurrent streams. The radiants lie close to the ecliptic and appear in progression following the visual η-Aquarid shower in early May. The sequence is dominated by the remarkable Arietid stream, active for some twenty-one days at the end of May, and in June with an hourly rate much greater than the night-time Perseids and Geminids[13].

The orbits of these streams are of very short period: they all lie inside the orbit of Jupiter and, apart from one, are of too short a period to coincide with anything known in the solar system, except perhaps some unusual minor planets. The one exception is the β-Taurid stream, active in midsummer, which coincides with the orbit of the unusual comet known as Encke's comet. This stream is of exceptional interest, since the plane of the orbit lies almost in the plane of the ecliptic. The earth therefore crosses this orbit before and after perihelion. From his photographic measurements on one of the autumn night showers—also with its radiant in Taurus—Whipple[14] concluded that this stream was associated with Encke's comet, and in 1942 made the remarkable prediction that the earth should cross the orbit again after perihelion, and give rise to another shower with its radiant close to the sun—"perhaps observable as fireballs in late June or early July". The β-Taurid stream found five years later by the radio echo technique is undoubtedly this return.

In summarizing this progress in meteor astronomy, it is evident that a considerable clarification has recently occurred. All meteors, at least those with visual magnitudes, can be assumed to be confined to the solar system. As to their origin within the solar system, it now seems certain that the general belief of an association between certain meteor streams and comets is correct. On the other hand, another origin, possibly associated with the minor planets, must be sought for the major part of the intense summer day-time meteor activity.

Galactic and Extra-Galactic Radio Emissions

The work already described is an example of the rapid advance which has resulted from the application of radio techniques to an already well-known subject in astronomy. On the other hand, the discovery of the extra-terrestrial radio emissions by Jansky[9] in 1932 opened a new subject in astronomy in which the contemporary results present a unique puzzle to astrophysicists. It was evident from the early measurements made by Jansky and by Reber[15] that the intensity of these emissions could not be explained as being the aggregate black-body emissions in the radio spectrum from the stars in the galaxy. Even after the discovery of the enhanced radio emissions from the sun, it was apparent that, if all the stars emitted enhanced radiation like the sun, then there still remained a factor of some 10^{10} to be accounted for in order to explain the intensity of the galactic emissions. Moreover, there did not appear to be any measurable emission from the brighter stars or other prominent objects in the galaxy. The intensity distribution followed the known features of galactic structure, being most intense from the direction of the galactic centre and at a minimum from the poles. These features led Reber to suggest that the radiation originated in the interstellar gas. For a variety of reasons, some of which are explained hereafter, it is now regarded as unlikely that an appreciable fraction of the total radiation originates in this manner.

Radio stars. In the pioneer measurements made in 1945 in Great Britain, Hey[16] noticed that the radiation from the direction of Cygnus showed fluctuations in intensity, and he suggested that this might be due to a variable source of radiation in this region. The evolution of the interferometer-type of radio systems by Bolton and Stanley[17] in Australia, and by Ryle and Smith[18] in Great Britain, not only confirmed the

existence of a localized source of radiation in Cygnus, but also has since shown that a large number of these localized sources, or radio stars, exist[19]. Unfortunately, the resolution of these instruments is poor by optical standards, and the diameters of the sources are only known to be less than 1 minute of arc. Even so, none of these radio stars coincides with any particular type of star already catalogued. In fact, the most intense sources in Cassiopeia and Cygnus are situated in regions devoid of stars brighter than eleventh magnitude. Bolton finds that three of the radio stars coincide with unusual objects in the galaxy (the Crab Nebula—the supernova of 1054, and the unresolved nebulosities *NGC* 4486 and *NGC* 5128), but it is generally believed that these are non-typical stars. For the remainder of the fifty to a hundred radio stars the positions of which have been determined so far, there are no particular coincident visual objects.

The question now arises as to whether these hundred radio stars so far delineated are merely the brightest of a great number of unresolved stars which form the diffuse background radiation, or whether other sources, such as the interstellar gas, are significant. Independent analysis made by Ryle and Smith[18], and by Bolton, indicates that the whole of the radiation can be explained if the few radio stars so far delineated are regarded as the most intense of a large number of radio stars, distributed through the galaxy in a similar manner to the distribution of the visual stars. The most recent experimental evidence supports this view, and we are thus faced with a possibility of the utmost cosmological importance, namely, that the galaxy contains large numbers of stellar objects which are not visible. The present estimate of the population density to be assigned to these radio stars differs somewhat; but it seems likely to be of the same order as the stellar density in our neighbourhood (0·1 per cubic parsec). There have been several speculations as to the mechanism by which a stellar object of low visual brightness could produce such intense radio emissions; but none is wholly acceptable. One great difficulty is the uncertainty as to the size of the radio stars—the present limits, of minutes of arc, are several thousand times larger than stellar diameters. Until such measurements are refined, the origin of these stars seems likely to remain one of the greatest contemporary problems in astrophysics.

Galactic structure. It is well known that the major parts of our galaxy must be for ever hidden from normal vision, even with the greatest telescopes, owing to the presence of the interstellar dust which obscures our view of the central regions of the galaxy. This dust presents no obstacles to the penetration of the radio waves, and it seems likely that we are on the threshold of obtaining the first really detailed picture of the structure of the local galaxy. The fundamental assumption which has to be made is that the intensity of the radiation from a given direction is proportional to the extent of galactic material in that direction. This would be the case, for example, if, as discussed above, the radiation came from radio stars of the same absolute magnitude uniformly distributed throughout the galaxy. The first attempt to present a general picture of galactic structure in this manner has recently been made by Bolton and Westfold[20]. Their results are consistent with the view that the local galaxy is a spiral, with the sun situated in or near the arm. It is unlikely that the detailed results in this aspect of the subject will be available for some years, since the exploration with really narrow pencil beams requires extensive aerial systems which are not yet available.

Twinkling of the radio stars. Hey first noticed that the radiation from the neighbourhood of Cygnus fluctuated in intensity whereas that from the rest of the sky appeared to be steady[16]. The subsequent discovery of a point source of radiation in this neighbourhood led to the belief that the fluctuations were due to variations in the emission from the source. Experiments in which the radiation has been recorded simultaneously on spaced receiver equipments have now shown that this belief is erroneous, and that the fluctuations are introduced when the radiation passes through the *F*-region of the ionosphere[21]. So far as is known at present, both the intense radio stars in Cassiopeia and Cygnus and the other stars so far identified emit with a steady intensity, but when the *F*-region is disturbed, fluctuations are introduced by a diffraction process. The occurrence of the fluctuations is closely associated with the incidence of the 'spread' or 'diffuse' *F*-echo phenomena, at which times the *F*-region is believed to become very disturbed. The cause of this 'patchiness' in the electron density is not known; but Ryle has suggested that it may be caused by the collection of interstellar dust[22]. In any event, the immediate effect on the incoming radiation from the radio stars is to give rise to the fluctuations in intensity, which appear to be strictly analogous to the twinkling of the visual stars. The detailed study of these fluctuations now provides a new and powerful technique for investigating the complexities of the disturbed *F*-region.

Radio emissions from the extra-galactic nebulæ. Although there have been various speculations on the possibility of detecting radio emissions from the external nebulæ, it is only during the past few months that a successful experiment has been made. Using the 220-ft. aperture paraboloid at Jodrell Bank in Cheshire, and a receiving system capable of measuring a noise input only 1/1500 of that generated in the receiving set, Hanbury Brown and Hazard[23] have shown that radio emissions are being received on the earth from the great nebula in Andromeda (*M*.31), which, at a distance of 750,000 light years, is the nearest of the extra-galactic nebulæ. The intensity of the radiation received on this equipment was only 1/150 of that from the intense radio star in Cygnus; nevertheless, sufficient results have been obtained to show that our own galaxy and the Andromeda nebula are very similar so far as the radio emissions are concerned. One is therefore now forced to the conclusion that there are no special features of our own galaxy which cause it to generate these radio waves, and, conversely, that the extra-galactic nebulæ also probably contain great numbers of radio stars.

This article has reviewed less than half the topics which are now embraced within radio astronomy. No mention has been made of meteor physics, or of the lunar work, or of the vast accumulation of results on the solar radio emissions which have such great value in the studies of solar and stellar atmospheres. Nevertheless, it should be evident that five years of post-war development in this subject have effectively opened a new epoch in astronomy and astrophysics. In conclusion, it should perhaps be emphasized that no attempt has been made to give a historical survey of the development of these topics, and hence it has not been possible to stress the utmost importance of

much of the early work. In addition to the pioneer work of Appleton, Skellett and Jansky, mentioned at the beginning, this account would not be complete without specific reference to the work of J. S. Hey and his colleagues who, using ex-army radar equipment in 1945 and 1946, reopened three of the main subjects—meteors[14], solar[15] and galactic radio emissions[16]—producing results which have been the foundation of much of the subsequent work.

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DEVELOPMENTS IN AGRICULTURAL FUNGICIDES

By R. W. MARSH

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IN the field of fungicides used on crop plants both the range of materials and the methods of application are showing rapid development, particularly in North America[1]. The standard general-purpose fungicides, principally inorganic compounds of sulphur, copper or mercury, are giving place to organic derivatives which are often more specific in their effects[2,3,4].

Range of Materials

Organic sulphur fungicides include tetramethylthiuram disulphide (thiram*) and the closely allied dithiocarbamates. Among such materials in common use in the United States are the ferric and zinc dimethyldithiocarbamates (ferbam* and ziram* respectively), and the disodium ethylene and zinc ethylene *bis*dithiocarbamates (nabam* and zineb*). Organic compounds of mercury newly employed as fungicides include phenyl mercury chloride, phenyl mercury acetate, and phenyl mercury monoethanol ammonium lactate. Copper-8-quinolinolate is an example of the organic copper fungicides.

A sharper break with tradition is the derivation of fungicides containing neither copper, sulphur nor mercury. Among the quinones, 2 : 3-dichloro-1 : 4-naphthaquinone and tetrachloro-1 : 4-benzoquinone have shown outstanding fungicidal value. Other fungicides have been discovered in the azoles, notably in derivatives of the pyrazoles and of the related iminazoles (glyoxalines).

The halogenated hydrocarbons include a number of newly developed fungicides such as 1 : 3-dichloropropene and chloropicrin. The chloronitrobenzenes are exceptional in being a new group of fungicides much better known in Great Britain than in the United States. A final category may be made of the numerous fungicidal antibiotics, as exemplified by gliotoxin, antimycin and actidione (*cyclo*heximide).

* Coined common names in general use in the United States, and recommended by the British Standards Institution for acceptance in Great Britain.

Relative Fungitoxicity

The relative merits of fungicides may be compared both at laboratory and at field levels. The fungicidal value assessed in the laboratory is only one of the factors contributing to the usefulness of a material, but sometimes provides a pointer to field performance. Table 1 gives results of a comparison of the germination of spores of the fungus *Sclerotinia fructigena* on glass slides sprayed respectively with four representatives of the newer fungicides and with two of the standard materials.

Table 1 (adapted from Byrde[5])

Fungicide	Mean E.D. 50 (μgm./cm.²)
A. Phenyl mercury chloride	0·0074
B. 2 : 3-Dichloro-1 : 4-naphthaquinone	0·030
C. Copper-8-quinolinolate	0·074
D. Standard laboratory Bordeaux mixture (as Cu)	0·21
E. Glyoxalidine acetates*	0·33
F. Lime sulphur	1·05

* 32 per cent 2-heptadecyl glyoxalidine acetate, 16 per cent 2-pentadecyl glyoxalidine acetate, 2 per cent 2-heptadecenyl glyoxalidine acetate, 50 per cent isopropanol.

In this laboratory assay, the relative fungicidal value of the materials, taking lime sulphur (*F*) as 1·0, could be expressed as: *A*, 142; *B*, 35; *C*, 14·2; *D*, 5·0; and *E*, 3·2.

Employments on Crop Plants

Fungicides are most widely used as foliage protectants. Table 1 suggests that certain of the newer fungicides might give effective field performance at relatively low concentrations when used as foliage sprays. An extensive range of trials in which control of apple scab disease was taken as a criterion indicates that a level of field control equal to that given by a lime sulphur spray at 1 per cent can be obtained from the newer fungicides at concentrations of the following orders: glyoxalidines, 0·3 per cent; naphthaquinone, 0·09 per cent; phenyl mercury chloride, 0·01 per cent. The practical usefulness of foliage fungicides is, however, also determined by their liability to cause spray damage. Commercial naphthaquinone preparations have, for example, frequently brought about delayed maturity, leaf bronzing and fruit spotting. On the other hand, the thiocarbamate materials, which in laboratory trials

against *Sclerotinia fructigena* spores show a lower fungicidal value than lime sulphur, are widely used in the United States on fruit, vegetable and flower crops, because of their low phytotoxicity.

A relatively new development in the employment of fungicides is their injection into soil to check the growth of root-attacking fungi. Trials of such methods on a field scale in the irrigated soils of California have shown limited success in the use of chloropicrin and 1 : 3-dichloropropene as fungicidal soil fumigants. These materials are too volatile for high temperatures and light soils, and are most successful in cooler conditions and heavier land. They show considerable specificity of action, and their effect may be exerted either directly on the pathogen or indirectly by modifying the soil population so as to favour micro-organisms antagonistic to root parasites.

An allied method of treatment is the application of a fungicide to seed beds, at or near the time of sowing, to protect the emerging seedlings from damping-off diseases. Preparations of tetramethyl-thiuram disulphide have been successfully used in this way on sugar beet in southern Ontario[6].

The same material is being widely applied as a dressing for seeds of flax, peas, beans, carrots and spinach. Tetrachlorobenzoquinone seed dressings are also used on peas and beans. The dressings for cereals have not shown any major change in the past decade, the standard materials employed being the organic mercurials, for example, ethyl mercury *para*toluene sulphonanilide, ethyl mercury phosphate, phenyl mercury urea and methoxyethyl mercury compounds. Work with fungicidal antibiotics on pea seeds infected with *Ascochyta pisi* suggests that certain of these materials in dilute solution are able to penetrate the testa and affect the mycelium within the seed.

New Means of Application

One result of using foliage sprays effective at low concentration is that the proportion of water to active ingredient may be of the order of a ton of water to a pound of fungicide. In attempts to find an escape from this burden of water dispersal, practices are being evolved in which air, steam or carbon dioxide may be used as the diluent instead of water. Such methods have been most successful in dealing with insecticides from which oil-dissolved concentrates can be prepared. In field applications, either from the air or from mobile ground equipment, the concentrate is 'atomized' into an airstream which carries the finely divided insecticidal deposit on to the foliage. Difficulties arise in applying this expedient to protectant fungicides, which have commonly a low oil solubility and are generally used as water suspensions which can be concentrated only to a limited extent. Further, the performance of protectant fungicides on plants depends on thoroughness of cover to a greater degree than does the performance of contact insecticides. Fungicides, moreover, are far more liable to cause damage if over-applied.

In dealing, for example, with fruit trees, the correct rate of application of an air-dispersed concentrate can be ensured only by adjusting the rate of travel of the machine past each tree according to the output of fungicide per second; there is no visual check either on under-spraying or over-spraying. These considerations offset the immediately apparent advantages of using fungicide concentrates; but the method has shown promise, particularly on ground crops, when the protectant has been used at not more than six times the conventional strength.

The dispersal of fungicide concentrates by the use of compressed carbon dioxide is applicable in enclosed spaces such as glasshouses, where preliminary experiments have been made with the use of 'aerosols' of phenyl mercury salicylate.

Systemic Fungicidal Action

It has recently been shown[7] that radioactive sulphur dusted on to lemon fruit penetrated the peel to a depth of 240 μ after 6 hr. at 140° F. There is also evidence that the thiocarbamates and possibly the glyoxalidines can enter the plant cuticle. The stage of further translocation of certain fungicides through plant tissues has now been established, and it has been shown that fungistatic effects can be exerted within plant cells by the translocated material. Systemic fungicidal action recorded up to the present has been less spectacular than that of the systemic insecticides, and usually takes the form of retardation of fungus development or provides an antidote of a toxin produced by the pathogen. Thus, in investigations[8] on Dutch elm disease, a solution of 8-quinolinol benzoate injected 18–24 in. below the soil surface in the feeding-root zone of infected trees temporarily suppressed the symptoms. In trials on potted tomatoes[9], plants grown in sand watered with *cyclo*pentenyl butyl dithiocarbamate and afterwards inoculated with *Fusarium Lycopersici* showed significantly less severe *Fusarium* wilt than the controls. In other trials on tomatoes[10], two pyrazole compounds (1-phenyl-3 : 5-dimethyl-4-nitrosopyrazole and its sulphamyl derivative) were taken in by sprayed leaves and translocated to other parts of the plant, where they reduced susceptibility to leaf spot caused by *Alternaria Solani*.

In Great Britain another line of approach has been followed by Crowdy and Wain[11], who selected aryl-oxyaliphatic acids known to be translocated but of low growth-regulating power, and tested their systemic fungicidal action. Young bean plants were grown with their roots in aqueous solutions of the test materials, and afterwards the leaves of these plants were sprayed with spore suspensions of *Botrytis cinerea*, the cause of the chocolate spot disease. It was found, for example, that 2 : 4 : 6-trichlorophen-oxyacetic acid applied in this way at 10 p.p.m. gave a mean reduction in the total area per plant of chocolate spot lesions of 36 ($\pm$ 7) per cent. The effect of the treatment was to check the growth of the individual lesions rather than to reduce the number of infections. In spite of these encouraging results with systemic fungicides, it would be misleading to suggest that the use of such substances has yet reached the stage of providing a practicable means of plant disease control.

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OBITUARIES

Mr. C. J. P. Cave

C. J. P. CAVE, who died suddenly after a short illness on December 8, was one of the pioneers in the investigation of the upper air, initiated by a joint committee of the British Association and the Royal Meteorological Society. Cave was born in 1871, educated at the Oratory School, Edgbaston, and Trinity College, Cambridge, and elected a fellow of the Royal Meteorological Society in 1899. Four years later he saw a letter in *The Times* from W. N. Shaw, chairman of the Committee mentioned, inviting the co-operation of voluntary observers, living in open country remote from towns, in flying kites carrying meteorographs for recording pressure, temperature and humidity. Cave volunteered, and provided, at Ditcham Park, Hants, his own gear for winding the miles of piano wire used in flying the kites, which, as well as the meteorographs, were designed by W. H. Dines. Soon, however, Cave felt the need for information about the wind at higher levels than kites could reach, and began a series of observations with pilot balloons. He used the theodolites invented by A. de Quervain and a base nearly two miles long. Already in 1908 he was able to show from his observations that the normal increase of wind with height stopped at the tropopause and was replaced by a rather rapid decrease in the stratosphere—a result in agreement with, though in advance of, the theoretical deduction from the reversal in the stratosphere of the horizontal temperature distribution in the troposphere. His book "The Structure of the Atmosphere in Clear Weather", published in 1912, was based mainly on his own observations at Ditcham Park.

During the First World War, Cave was commissioned as captain and, after a short period of service in France, he took charge of the training of personnel for service with the meteorological sections in France and the Middle East. In this work his special knowledge of the upper air was particularly valuable.

Cave was an expert photographer of clouds; he published some of his photographs in 1926 in his small but enlightening book on "Clouds and other Weather Phenomena", a new edition of which was issued in 1943. In later years, he applied his skill to the photography of the roof bosses, the sculptured keystones of the arched roof-ribs, in medieval churches. A selection of these (354 British and 12 French) was published in 1948, with seven descriptive and critical chapters of text in a book which had an enthusiastic reception.

Cave was twice president of the Royal Meteorological Society, president of the Hampshire Field Club and Archæological Society, and chairman of the Petersfield divisional bench of magistrates. His quiet, courteous bearing and generous nature endeared him to all who knew him. E. GOLD

Mr. Guy O. Harrison

THE death on December 5 is announced of Mr. Guy O. Harrison, for many years senior technical assistant in the Department of Physics in the University of Birmingham. He was associated with J. H. Poynting in the old Mason College days, when Poynting was still engaged in his studies of gravitation, and remained until his retirement in 1938. He was an ingenious and skilful craftsman, especially in the construction of apparatus for research. His resourcefulness was indeed necessary at a time when the only machine tool in the Physics Department workshop was a second-hand lathe driven by an old gas-engine.

Harrison became an expert glass-blower, and when Röntgen discovered X-rays, Poynting instructed Harrison to make an X-ray tube; with this tube he took some of the earliest radiographs made in Great Britain. The opportunity was eagerly seized by distinguished surgeons associated with the Queen's and General Hospitals at Birmingham for the application of the new discovery to surgical practice, and Harrison's radiographs must have been some of the first of their kind. The surgeons were enthusiastic when a needle was precisely located in the hand of a girl, and more requests for help in diagnosis flowed in. More fortunate than his contemporary, Hall-Edwards, another Birmingham man and a pioneer in X-radiography, Harrison narrowly escaped the dermatitis which was contracted by Hall-Edwards.

On the discovery of quartz fibres by Boys, Poynting asked Harrison to make some of these useful articles, an operation in which he soon became proficient. He gave valuable help in the construction of the apparatus for the researches of Poynting and Barlow on the pressure of waves of light, and in Poynting's last work, on the changes in dimensions of steel wires on twisting and on the pressure of torsional waves in steel; Harrison not only made the apparatus but also assisted in the observations. He was, in fact, one of those necessary adjuncts to a physics department whose value is to-day recognized by the authorities who control wages—a recognition which was of very tardy growth.

Mr. Harrison's wife died in March last, and he never quite recovered from the shock. He is survived by his elder son, his younger son having been killed in the War. G. A. SHAKESPEAR

Mr. Percy Good, C.B.E.

HAVING known Percy Good intimately for more than forty years, and imagining him quietly recuperating at home from much overwork, it was a great shock to learn of his death on December 2.

Percy Good was born in London in November 1880. He left the City of London School in 1897, and the City and Guilds Central Technical College in 1900 with the diploma for electrical engineering. He was later elected a fellow of the College.

He and I were together for a couple of years in the old Thames Iron Works, after which he took up an appointment under the late Dr. Alexander Russell at Faraday House as superintendent of the testing department. Subsequent to this, he started in private practice as a consultant. His work for the most part was concerned with the installation of electric light and power in large private houses and public buildings, in which he was very successful.

Percy Good joined the Engineering Standards Committee, as it was then called, in 1913, and later became assistant secretary in charge of all the electrical work being carried on by the Committee. In 1916 the Committee suffered the great loss of its first secretary, Leslie Robertson, who went down in H.M.S. *Hampshire* when she was torpedoed in the North Sea on her way to Russia with Lord Kitchener. I succeeded him, and Percy Good became, as it were, second in command. With his initiative and genius

for organization, he was of the very greatest help in the many difficult problems we had to meet, particularly after the First World War, when the British Engineering Standards Association, as it had become, was very hard pressed for the funds necessary to carry forward its fast-growing commitments.

In 1929, the benefits of industrial standardization on a national basis were becoming more generally recognized. Requests for national specifications basic to branches of industry outside engineering were being received and acted upon, and eventually a royal charter was granted to the organization, the title being changed to the British Standards Institution as being more representative of its wider aims. It was in that year that Percy Good became deputy director, a post which he filled with ability and distinction until 1942, when he succeeded me as director.

In 1947, Percy Good was elected president of the Institution of Electrical Engineers. In 1945 he was made C.B.E. for his work as chairman of a joint committee of the Ministry of Home Security and the Illuminating Engineering Society. He was a member of the executive committee of the National Physical Laboratory and of the board of the Polytechnic, Regent Street, London. To the end he was wholeheartedly devoted to the progress of the British Standards Institution, to which he had contributed so much. All who came in contact with him, both at home and abroad, will mourn the loss of an enthusiastic colleague who, apparently, never stopped working day or night. C. Le Maistre

Captain E. H. Gregory

We regret to record the death on January 5 of Captain Edgar Gregory, the only son of Sir Richard Gregory, formerly editor of *Nature*.

Captain Gregory was fifty-nine years of age. He was educated at Churcher's College, Petersfield, and at Wye and Sandhurst Colleges. He served with the Suffolk Regiment during the First World War and retired in 1925. Then he joined the staff of Rothamsted Experimental Station and took up a post in the field experiments section. He was mainly concerned in explaining the Rothamsted work to parties of farmers and technical people visiting the farm, and his demonstrations, given with characteristic humour, must be remembered by many. He was also active in the early development of the field experiments at outside centres, where his genial personality and ready wit stood him in good stead and he made many friends. Gregory left Rothamsted in 1939 on being called back into the Forces, and after the Second World War transferred to the Ministry of Agriculture, where he worked in the Press and Public Relations Division.

NEWS and VIEWS

Institution of Electrical Engineers: Awards

The Institution of Electrical Engineers has elected Mr. P. V. Hunter, past-president, to honorary membership of the Institution for his outstanding services to the electrical industry and to the Institution. The twenty-ninth award of the Faraday Medal of the Institution has been made to Mr. T. L. Eckersley, for his achievements in the field of radio research and, in particular, for his outstanding contributions to the theory and practice of radio-wave propagation.

Mr. P. V. Hunter, C.B.E.

Mr. Hunter received his technical training at Faraday House and with the firm of Willans and Robinson. After gaining practical experience with several firms, in 1919 he was appointed joint manager and chief engineer of Callender's Cable and Construction Co., Ltd., becoming a director in 1937. He is now deputy chairman of B.I. Callender's Cables, Ltd., and chairman of B.I. Callender's Construction Co., Ltd. Mr. Hunter has devoted special attention to the development of electrical transmission; he is the inventor of the split-conductor and several systems of automatic discrimination for electric-power transmission systems and improved forms of transmission cable. He has, for many years, been chairman of the National Register of Electrical Installation Contractors, and has represented the Institution on several committees. During the First World War he was engineer-director to the Experiments and Research Section of the Anti-submarine Division of the Naval Staff, and his invention early in the Second World War of the buoyant cable contributed largely to the defeat of the magnetic mine. Mr. Hunter's long association with the Institution commenced in 1910 when he was elected an associate; he was president during 1933–34. He is also a fellow of the American Institute of Electrical Engineers.

Mr. T. L. Eckersley, F.R.S.

Mr. Eckersley was educated at Bedales School, University College, London, and Trinity College, Cambridge, and joined the National Physical Laboratory in 1910. After serving with the Royal Engineers on wireless intelligence in Egypt and Salonika during the First World War, he joined the Marconi Wireless Telegraph Co., Ltd., and his work with that Company has been chiefly concerned with radio-wave propagation. During the Second World War he was seconded to the Air Ministry. Among Mr. Eckersley's outstanding achievements have been his prediction of the performance of short-wave services, including the enunciation of a theory of the diffraction of waves round the earth taking into account the earth's resistance, and the application of phase-integral theory to propagation problems. By another method he produced a theory of propagation in the ionosphere, and his experiments in connexion with the interpretation of random echoes from the ionosphere led him to his now well-known theory of scattering. He was also the first to employ the method of spaced frames to achieve a direction-finding system substantially free from polarization errors. Mr. Eckersley was elected to the Royal Society in 1938; on four occasions he has received the Duddell Premium and he has also been awarded the Kelvin Premium of the Institution.

James Watt International Medal of the Institution of Mechanical Engineers: Dr. H. H. Blache

The Institution of Mechanical Engineers has awarded the James Watt International Medal for

1951 to Dr. H. H. Blache, of Denmark, for his contributions to the advancement of mechanical engineering, and particularly for his pioneer work in the development of the large marine diesel engine. Dr. Blache was nominated by the Danish Society of Engineers. The Medal, which is in gold, was founded in 1936 to commemorate the bicentenary of the birth of James Watt, on January 19, 1736, and is the highest honour the Institution can bestow. It is awarded every two years for distinction in mechanical engineering in any direction—science, research, invention or production.

Thomas Young Oration of the Physical Society

Dr. W. D. Wright, of the Imperial College of Science and Technology, London, will deliver the Physical Society's Thomas Young Oration for 1951. This Oration is a biennial event which is devoted alternately to physical and physiological optics. Dr. Wright's subject is "Modern Problems in Colorimetry", and the Lecture will be given in the Science Museum, Exhibition Road, London, S.W.7, on February 23 at 5.30 p.m. Apart from some work in the United States with Zworykin and others on television cameras, during which he designed a very successful type of Kerr cell, Dr. Wright's main research field over a period of twenty-four years has been the subject of vision—especially colour vision. For the study of normal and abnormal colour mixture data, he designed a new trichromatic colorimeter with spectral primaries, and the results obtained with this apparatus were employed (in association with data due to Guild) to define the standard colour-mixture data adopted by the International Illumination Commission. Besides a complete survey of abnormal colour vision, he has done work on the luminosity curve of the eye both for the foveal and extra-foveal areas (and also with very restricted fields) and on the sensitivity of the eye to differences in hue and differences in chromaticity. Dr. Wright's interest in colour has included the technical aspects of colour measurement, including the improvement of practical systems for use in industrial and commercial operations, and these aspects are discussed in his book "The Measurement of Colour" (1944). In more recent years his interests have included studies of the saccadic movements of the eyes during fixation, and also of the role of convergence in stereoscopic vision.

Geography in the Australian National University: Prof. O. H. K. Spate

Dr. O. H. K. Spate, reader in geography in the London School of Economics and Political Science, has been appointed to the chair of geography in the Research School of Pacific Studies at the Australian National University, Canberra. Dr. Spate had a brilliant academic career at Cambridge. In 1937 he was awarded his doctorate for a thesis on "London 1801–51: a Study in Urban Geography". This was followed by five years as lecturer in the University of Rangoon. The war years caused an interruption in his academic career, and he was attached to the Inter-Services Topographical Department, S.E.A.C. in charge of the Burma section. During this time, Dr. Spate gained first-hand knowledge of India, Pakistan, Burma and Ceylon. Since the War, Dr. Spate's main interests have been in the regional and political geography of monsoon Asia. In 1947 he was associated as a technical adviser with the Punjab Boundary Commission. In recognition of his work on India and Burma the Royal Geographical Society awarded Dr. Spate the Gill Memorial in 1947. The subjects of Dr. Spate's published papers include many geographical topics related to Burma, India and Pakistan. He is also co-editor of the "Changing Map of Asia: a Political Geography", which is to be published soon. Dr. Spate expects to arrive in Canberra in June.

Exhibition of Recent French Scientific and Technical Publications

An exhibition of recent French publications in science and technology, under the auspices of the French Embassy, was opened by Mr. J. D. Newth, president of the Publishers' Association, in the Science Library, South Kensington, on January 12. In welcoming the exhibition, Dr. Sherwood Taylor, director of the Science Museum, referred to the achievements of French men of science from the thirteenth century onwards, leading through those of the galaxy of mathematical astronomers of the eighteenth century up to those of two outstanding men of recent times, Pasteur and Poincaré. He also pointed out the contributions made by Frenchmen to the literature of technology, mentioning particularly Diderot and D'Alembert, and Dumas. In replying, M. René Varin, cultural counsellor to the French Embassy, apologized for the smallness of the exhibition, mentioning the great losses in young scientific workers sustained by France during the War. He referred to the great respect with which France regards English experimental science, as evidenced by the fact that at the present time nearly one hundred French scientific workers are carrying out research in Great Britain. In opening the exhibition, Mr. Newth congratulated the French publishers on the fine quality of the works displayed. He referred to the constant struggle waged by the Publishers' Association in Great Britain to reduce the restrictions imposed by various countries on the import of books; this, with the help of Unesco, has recently had some success. The exhibition will remain open until January 23, after which it will tour a number of university towns.

British Insecticides and Fungicides

The Association of British Insecticide Manufacturers has issued a useful "Directory, 1950: British Insecticides and Fungicides" (pp. 124; obtainable free, from the Association, 166 Piccadilly, London, W.1, 1950), which is intended mainly for use by overseas firms and organizations, but will also be found useful in Great Britain. The Association works jointly with the Ministry of Agriculture in the latter's scheme for the approval of proprietary products for crop protection. Section 1 of the Directory gives full details of member firms. Section 2 is a reproduction of colour plates from Bulletin 137 of the Ministry of Agriculture and Fisheries, showing stages of fruit bud development. Section 3 is a directory of products and services. It is divided into several sub-sections, each with brief descriptive notes, and ranges from aerial application substances to aerosols, and from fumigants to weed-killers and tree-wound paints. Names of the firms which supply each substance are listed, and the Directory is extended to include auxiliary agents such as wetters, spreaders and stickers. The publication is commercial rather than technical; but many advisory officers and others will find it useful. The introduction and salient headings are in six languages.

High-Frequency Electrical Research in Japan

A welcome sign of the renewal of scientific research in Japan is the publication of the first number of a new series of monographs by the Research Institute of Applied Electricity, of Hokkaido University, Sapporo. This number, entitled "Theory and Application of High-Frequency Phenomena" (edited by Prof. Y. Asami; pp. 68, 1950), consists of a group of six papers all centring around the general theme of the behaviour of materials in radio-frequency fields. Work on frequency-selective heating (previously reported briefly in *Nature*, **165**, 195; 1950) is here recorded in detail by Prof. K. Higasi and Y. Ozawa. There are papers giving much experimental information on the dielectric constant and conductivities of rabbit tissues, and particularly blood and its constituents, and also on the drying of a Japanese wood by electric fields at frequencies of 50 c./s. and 10 Mc./s. T. Matsumoto gives a theoretical study of the degree of electromagnetic shielding to be expected from the use of enclosures bounded by wire netting; the variation of the screening effect with frequency, size of wire, size of mesh, and a change from iron to copper wire, in cases of practical interest are clearly brought out. The subject as a whole is reviewed by Prof. Y. Asami, director of the Institute.

Bibliography of Scientific Publications of South Asia

Following the precedent of the Middle East Science Co-operation Office, the Science Co-operation Office for South Asia has issued a Bibliography of Scientific Publications of South Asia, covering India, Burma and Ceylon, which should be of real interest to the scientific worker and to the librarian (No. 1, January–June 1949. Pp. vi+107. Delhi: Unesco Science Co-operation Office for South Asia, 1950). All branches of science, pure and applied, are included, special attention being given to papers reporting original research. Some of the periodicals covered are not available in the Office collection or in the libraries of Delhi; but short résumés of any entry of particular interest to any scientific worker can be supplied upon request to the Office. Entries are arranged under the broad classes of the Universal Decimal Classification; but there are at present no cross-references. An author and a subject index are contemplated later. A list of scientific periodicals covered, arranged under India, Burma and Ceylon, giving the abbreviations used, rate of subscription and publisher's address is included, and separate sections will be issued for the other South Asian countries. The first number covers the period January to June 1949, but includes some 1947 and 1948 references.

National Museum of Canada: Annual Report for 1948–49

It is seldom that an annual report of a museum contains such a wealth of original papers as that of the National Museum of Canada for 1948–49 (National Museum of Canada Bulletin No. 118; pp. 120+23 plates; Ottawa: King's Printer, 1950; 25 cents). As well as the more usual details regarding accessions, additions to the display in the exhibition halls, and educational work often of a novel character, the results of field work in many directions are described by those concerned. These include: ethnological investigations carried out in British Columbia, Quebec and Nova Scotia; archæological research in the Prairie Provinces, the Yukon, northern Quebec and on Baffin Island; studies of birds and mammals in south-western and central western Saskatchewan; and botanical work in Manitoba and the Yukon.

Announcements

Dr. O. H. Wansbrough-Jones, scientific adviser to the Army Council since 1946 (see *Nature*, **157**, 688; 1946), has relinquished this post in order to take up that of principal director of scientific research (defence) at the Ministry of Supply.

Mr. J. Mull, who has been for the past five years with the Technical and Scientific Register of the Ministry of Labour, has been appointed registrar and secretary of the Professional Engineers Appointments Bureau, 9 Victoria Street, Westminster, S.W.1, in succession to Dr. H. J. Nichols, who has resigned.

The following have been elected officers for 1951 of the British Glaciological Society: *President*, G. Seligman; *Vice-President*, J. M. Wordie; *Honorary General Secretary*, A. H. Bolitho (c/o Royal Geographical Society, Kensington Gore, London, S.W.7); *Honorary Treasurer*, T. H. Best; *Meetings Secretary*, D. S. Brock.

The second annual conference of the Society for the Study of Fertility will be held at Girton College, Cambridge, during June 20–21. Further particulars can be obtained from the secretary, Dr. G. I. M. Swyer, University College Hospital Medical School, London, W.C.1.

A discussion on "Recent Controversies in Soviet Medical Theory", based on the work of Pavlov, A. D. Speransky, Bykov and O. B. Lepeshinskaya, has been organized by the Medical Committee of the Society for Cultural Relations with the U.S.S.R., and will be held at 8 p.m. on January 29 at 14 Kensington Square, London, W.8. Tickets, price 1*s.* 6*d.* (S.C.R. members and students, 1*s.*), are obtainable from the Society at the above address.

During April 9–14, Aslib is holding a course of lectures at Chaucer House, Malet Place, London, W.C.1, similar to that organized in previous years, for beginners in information and special-library work. There will be five lectures, each in the afternoon (preprints will be available), and in the morning visits will be paid to a number of specialized libraries. There will also be some discussion groups. The fee for the whole course is £2 2*s.* or, for a single day, 14*s.* (non-member surcharge, 10*s.*). Further details can be obtained from Aslib, 4 Palace Gate, London, W.8.

The annual convention of the Institution of Chemical Engineers will be held during April 11–15 at Nutford House, Brown Street, London, W.1. The theme of the convention is "Chemical Engineering—Opportunities in Specific Industries", and a number of lectures, each on a particular industry, have been arranged. Registration forms for the convention are obtainable from the Convention Secretary, Institution of Chemical Engineers, 56 Victoria Street, London, S.W.1, and must be completed before February 10.

Referring to the review of "Chemical Engineers' Handbook" in *Nature* of January 6, p. 4, the publishers, the McGraw-Hill Publishing Co., Ltd., state that the price of the American edition is 127*s.* 6*d.*; an English edition, a facsimile of the American book, has been recently produced at 107*s.* 6*d.* The page dimensions of the book are 10 in. × 7 in., and not as stated in the review.

X-RAY SENSITIVITY OF *E. COLI* AS MODIFIED BY OXYGEN TENSION

By Dr. ALEXANDER HOLLAENDER, G. E. STAPLETON and F. L. MARTIN
Biology Division, Oak Ridge National Laboratory

THE experiments of Thoday and Read[1], Hayden and Smith[2], as well as the older work of Crabtree[3], Mottram[4], and Anderson *et al.*[5], indicated a decrease of radiosensitivity of living cells if irradiated under reduced oxygen tension with high-energy radiation such as X- or gamma-rays. The effect of oxygen tension on X-ray sensitivity of rats has been reported by Dowdy and Bennett[6]. Recent quantitative studies at this Laboratory have brought out many interesting points in regard to this phenomenon. Giles and Riley[7] have shown a quantitative reduction of chromosomal aberrations in *Tradescantia* produced by X-rays if irradiation was carried out at less than normal oxygen concentration. Baker and Sgourakis[8] showed that, under similar conditions, gene mutation-frequency in *Drosophila melanogaster* is reduced. The duration of X-ray induced mitotic inhibition in the grasshopper neuroblast is decreased by reducing oxygen tension during irradiation[9]. It seemed desirable to extend this investigation to bacterial cells, with which there is a greater possibility of demonstrating the influence of metabolism on X-ray sensitivity.

Suspensions of *E. coli*, strains *B* and *B/r*, grown for 24 hr. in aerobic broth cultures, were used in preliminary experiments. In later experiments the influence of cultural conditions on sensitivity was studied. The cells were washed free of the nutrient broth, suspended in *M*/15 phosphate buffer and irradiated at 2° C., except where temperature effects were studied. The oxygen tension was lowered by evacuation of the bacterial suspension in a simple device which allowed saturation with the following gases: nitrogen, helium, hydrogen, or carbon dioxide. Exposures were made with 250-kV. X-rays (3-mm. aluminium inherent filtration) at 40,000 r./hr. None of the treatments preparatory to irradiation had any detectably injurious effect on the bacterial cell. Lowering the oxygen tension of the bacterial suspension, independent of whether oxygen is replaced by nitrogen, hydrogen, helium or carbon dioxide, results in a striking decrease of radiosensitivity of the cells, as compared with oxygenated suspensions. The order as well as the slope of the survival curves are different under low and high oxygen-tensions (Fig. 1). Irradiation of the medium, with energy values used in these experiments and with subsequent inoculation with bacterial cells, failed to yield any detectable residual lethal effect. The ratio of sensitivity, that is, ratio of dose in nitrogen to dose in oxygen-saturated suspensions that produced the same quantitative lethal effect, was found to be about three.

In an attempt to distinguish between the radiation effects produced through the intermediate aqueous suspension and those which are concerned with the bacterial cell as such, various cultural conditions were studied which might alter the recognizable effect on the cell. Cells were cultivated aerobically and anaerobically in the presence and absence of glucose added to nutrient broth ('Difco'), and their relative sensitivities to X-rays compared. Glucose cultures were buffered in order to maintain a *p*H of 6·8. For convenience the cells grown under various cultural conditions will be referred to as 'aerobic' or 'anaerobic broth' cells and 'aerobic' or 'anaerobic glucose' cells. Aerobic glucose cells showed a different X-ray sensitivity in oxygen and nitrogen from aerobic broth cells; but the ratio of sensitivity in nitrogen as compared with oxygen was essentially the same. Anaerobic glucose cells were found to be extremely resistant to X-rays if exposed in nitrogen. Moreover, anaerobic glucose cells exposed in oxygen were more resistant to X-rays than either aerobic broth or aerobic glucose cells.

Figs. 1 and 2 are plots of results obtained for the various systems described. It is important to point out several features of these curves. At a constant X-ray dose of 60,000 r. the difference in sensitivity on the basis of relative survival is of the order of 10^6 for aerobic broth bacteria irradiated in a suspension saturated with oxygen, as compared with anaerobic glucose bacteria irradiated in nitrogenated suspensions. Many additional observations not mentioned in this article indicate that cells, regardless of the method of culture, when exposed in oxygen-saturated buffer, give inactivation curves with essentially the same slope once the threshold dose is accumulated, this threshold being characteristic of the method of culture (that is, whether glucose was supplied or whether culturing was carried out aerobically or anaerobically). All curves obtained with bacteria grown in a variety of ways but irradiated in the absence of oxygen, independent of the gas used, are

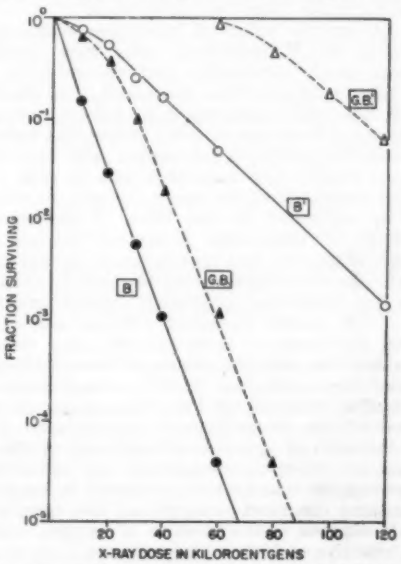

Fig. 1. Comparative sensitivity of aerobic and anaerobic cells irradiated in high and low oxygen-tensions
Curve *B*, aerobic broth cells irradiated in oxygen-saturated buffer; Curve *B'*, aerobic broth cells irradiated in nitrogen-saturated buffer; Curve *GB*, anaerobic glucose cells irradiated in oxygen-saturated buffer; Curve *GB'*, anaerobic glucose cells irradiated in nitrogen-saturated buffer

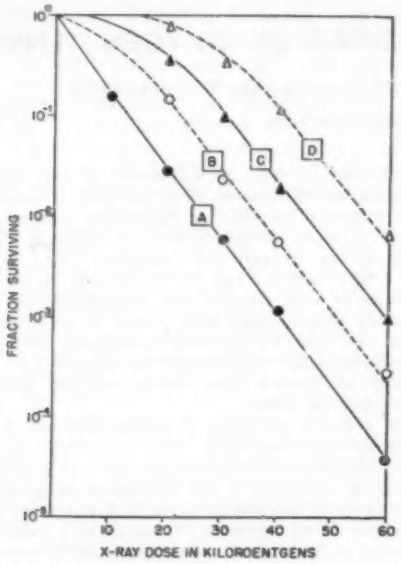

Fig. 2. Effect of cultural conditions on X-ray sensitivity, all cells irradiated in oxygen-saturated buffer
Curve *A*, aerobic broth cells; Curve *B*, anaerobic broth cells; Curve *C*, aerobic glucose cells; Curve *D*, anaerobic glucose cells

again parallel but have slopes entirely different from those obtained with cells irradiated in oxygen. No recognizable killing effect is produced in anaerobic glucose bacteria irradiated in the absence of oxygen at threshold values of about 60,000 r., whereas at this energy value aerobic broth cells irradiated in oxygen are almost completely inactivated. This would indicate that different mechanisms may be operative under these two conditions.

To clarify the effect of anaerobic culturing on sensitivity to X-irradiation, cells were grown in nutrient broth aerobically and anaerobically and their relative sensitivities compared. As shown in Fig. 2, anaerobic culturing does, indeed, reduce the sensitivity of broth-grown cells; in fact, the difference of sensitivity compares favourably with that found between aerobic and anaerobic glucose cells. The extreme resistance of the anaerobic glucose cells can then be explained on the basis of the complete additivity of these two protective systems: (1) presence of glucose, and (2) absence of oxygen during growth. It was observed that bacteria irradiated in broth are somewhat protected against irradiation effects. A careful study of different amino-acids showed that most of them provide some degree of protection, but that the most pronounced effect was obtained with cysteine. This is in agreement with the results obtained by Patt[10] in regard to modification of the sensitivity of mammals to X-rays after injection of cysteine. Preliminary results concerning the effect of temperature on sensitivity to X-rays indicate that bacteria irradiated in oxygenated suspensions are most sensitive at low temperature (2° C.), whereas, in the absence of oxygen, cells are most sensitive at higher temperatures.

A relationship between sensitivity to X-rays and bacterial concentration in irradiated suspensions is clearly indicated, cells becoming more sensitive with decreasing concentration. The effect is most pronounced where the concentration of bacteria is 10^7 cells/ml. or less. This correlation demonstrates the relative importance of the 'indirect effect' in radiation inactivation of bacteria.

These experiments show, among other things, the importance of (*a*) oxygen tension in the suspensions, (*b*) the state of oxidation or reduction inside the organism during exposure to X-radiation, and (*c*) the possible modifying effect of the types of metabolism carried out by the organism before irradiation. Most of the results are consistent with the idea that radiodecomposition products of water are contributing toxic agents, for example, hydrogen ions, hydroxyl, HO_2, hydrogen peroxide[1,7-11], some of which are produced only in the presence of oxygen during irradiation. However, it is felt that not all the findings in regard to oxygen concentration can be explained on this basis, as the production of such products has been demonstrated only with pure water. We know very little of the modifications which might take place inside living cells, where there exists a very complicated medium containing enzymes and amino-acids, as well as many other organic and inorganic components. These points will be discussed in greater detail in another publication.

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A METHOD FOR PRODUCTION OF INTERFERENCE FILTERS FOR SPECIFIED WAVE-LENGTHS

By A. THERMANSEN

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IN the production of interference filters by evaporation in high vacuum, two major problems arise. The first is to obtain a uniform thickness of the dielectric layer over a sufficient area. A band-width of 50–100 A. requires that the variation in thickness must be less than 0·5 per cent, from the general formula for interference filters developed by Hadley and Dennison[1]. The second problem concerns the control of the thickness of the layer during evaporation in order to be able to make a filter for a given wave-length, for example, corresponding to strong spectral lines of common elements. Of course, this control also should be accurate to less than 0·5 per cent.

In order to solve these two problems, an evaporation apparatus was built, as shown schematically in

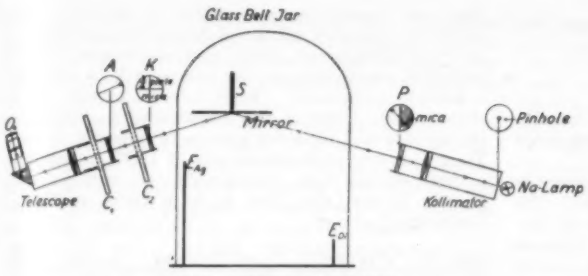

Fig. 1. Diagram of apparatus.

O_1, ocular; C_1 and C_2, graduated circles; A, analyser ('Polaroid' plate); K, compensator (quarter-wave mica plate); P, polarizer ('Polaroid' plate); S, shaft; E_{Ag}, evaporation source for silver; E_{Di}, evaporation source for dielectric

Fig. 1. To secure constancy of the layer, the glass plate was rotated during the evaporation, as was first done by Fisher and Platt[3] for silvering interferometer mirrors. Great care must be taken that the shaft S is perpendicular to the plate, which was rotated by a little motor placed inside the glass bell jar. The evaporation sources for silver, E_{Ag} and dielectric E_{Di} respectively, were arranged according to the formula used by Strong[3] in order to secure constancy of the silver layers to about 4 per cent and of the dielectric layer to about 0·5 per cent. By this method good filters 8 cm. × 8 cm. could be obtained, using a bell jar of diameter 24 cm., when an efficient high-speed vacuum pump was used, as variations in pressure caused by the evaporation process are of very great importance.

A rough control of the thickness of the dielectric layer during the evaporation is usually performed by estimating visually the colour change of white light by reflexion from an unsilvered glass test-plate. A much better method, published by Greenland and Billington[4], is based on direct spectroscopical control using total reflexion from the dielectric layer. This method, however, is difficult to combine with the rotation arrangement.

In the present work a polarimetric method was used, based on the changes in phase occurring by reflexion of linearly polarized light from the evaporated layers. This method has the advantage that all control apparatus could be placed outside the bell jar. Further, the control could be achieved during the rotation with an accuracy of 0·5 per cent.

The theoretical background for this method goes back to Drude[5], and convenient formulæ for calculation of the phase difference are given by Vašiček[6]. Rothen[7] and Rothen and Hanson[8] have used a similar method, called an 'ellipsometer', for measuring the thickness of thin-surface films on stainless-steel plates, and have calculated curves giving the phase difference Δ as a function of the thickness of the dielectric film and tested the curves for thicknesses varying from 25 to 40,000 A.

As these thicknesses include the region of interest for interference filters, a similar method for control was attempted. The first step was to make numerical calculations for the phase differences for the dielectrics in question in relation to silver, that is, for fluorides and zinc sulphide (index of refraction 1·2 and 2·3, respectively; the complex index of refraction for silver 0·18–3·64i for Na-light). The results for an angle of incidence $\varphi = 75°$ are plotted in Fig. 2 as a function of the optical path differences x.

The relation between the transmitted wave-length λ_m (of order m) and the thickness d of dielectric of an interference filter[1] is

$$m \cdot \lambda_m = 2d\, n_D + \frac{y_s \cdot \lambda}{2\pi},$$

from which $\Delta\,(\lambda_m . m) = \dfrac{\lambda_s . \Delta x}{2\pi . \cos\theta}$

($y_s . \lambda/2\pi$ being almost independent of the wave-length λ). It is seen (from Fig. 2) that for values of x between $0{\cdot}6\pi$–$1{\cdot}2\pi$ and $1{\cdot}4\pi$–$2{\cdot}0\pi$ (the steep parts of the curve) a change of 1° of Δ corresponds to a change in $(m.\lambda_m)$ of about 15 A. for fluorides with $n_D = 1{\cdot}2$; for zinc sulphide conditions are even more favourable. For the values where Δ is a maximum (minimum) there is great uncertainty in thickness determinations. However, the wave-length λ_s can be chosen in such a way that all values of the dielectric thickness can be determined.

Fig. 1 shows the experimental arrangement. A half-shadow field is obtained by covering half of 'Polaroid' plate P with a piece of mica, one extinction direction of which is nearly parallel to the vibration direction of the polarizer P. The quarter-wave plate K must always be set near 45° (varying between 42° and 48° because the index of refraction for silver is so small that $\tan\psi = OP/OS$ is nearly unity in all cases of interest). As the shadow is rather sharp, an accuracy of 0·5° can easily be obtained. The accuracy with which a filter of a given wave-length could be reproduced by this method was only a little less than could

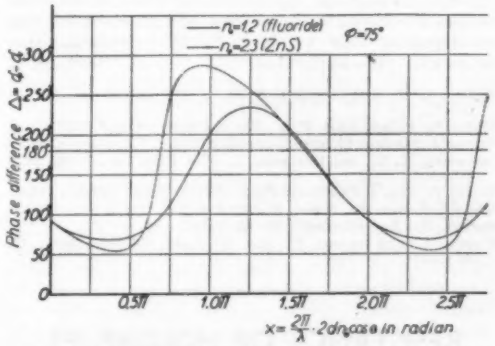

Fig. 2. n_D, index of refraction of dielectric; φ, angle of incidence; θ, angle of refraction, $\sin\theta = \sin\varphi/n_D$; d, thickness of dielectric layer; Δ, phase difference between the components OP and OS of the electrical vector parallel and perpendicular to the plane of incidence

be expected from Fig. 2. Fluctuations of about 20–30 A. (on rare occasions 60 A.) were observed on making filters of the second order. This is believed to be due to small variations in the reflecting power of the silver, but mainly to small variations in the index of refraction of the dielectric, due to small variations in pressure. A two-inch mercury diffusion pump was employed, the speed of which was rather small.

It has further been possible to determine the index of refraction of the dielectric layers by making two interference filters with a difference in thickness corresponding to a phase difference of 2π in Δ. It can be shown that

$$n_D = \frac{\sin\varphi}{\sqrt{1 \div \left(\frac{\lambda_0}{m_2\lambda_2 - m_1\lambda_1}\right)^2}} \quad \text{(when } \lambda_1 \text{ is chosen near } \lambda_2\text{)}.$$

$m_1\lambda_1$ and $m_2\lambda_2$ were measured spectroscopically immediately the filters were finished. Repeated measurements on cryolite gave $n_D = 1{\cdot}20$.

Shortly after a fluoride filter is produced, there is a shift of the transmitted wave-length towards the red in a rather unpredictable manner of about 50–100 A. On cementing a cover glass with Canada balsam over the filter in order to protect the silver layers, a wave-length shift of about 400 A. towards the red results. This shift must be taken into account when producing a filter for a given wave-length. The fluctuations indicated above relate to the finished filter cemented to a cover glass.

The explanation of this effect is believed to be that the fluoride layer is porous (the index of refraction of a cryolite crystal is 1·36). On cementing the cover glass, the pores are partly filled with Canada balsam and the index of refraction is raised from 1·20 to about 1·30.

A few filters with zinc sulphide as dielectric layer were also made. The wave-length was easy to reproduce. The index of refraction of zinc sulphide as determined by the above procedure turned out to be 2·26, in good agreement with measurements on crystals, showing that the zinc sulphide layer is not porous at all. Consequently, there was no shift in wave-length on cementing with Canada balsam.

The investigation is being continued and further details will be published elsewhere.

I wish to express my thanks to Prof. Ebbe Rasmussen for helpful discussions and interest in this investigation, and to Mr. P. W. Streander for constructing the apparatus. [July 8.

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RESISTANCE OF HOUSEFLIES TO DDT

By F. P. W. WINTERINGHAM, PATRICIA M. LOVEDAY and A. HARRISON

Pest Infestation Laboratory, London Road, Slough, Bucks

RECENT studies[1,2,3] by means of colorimetric and spectrophotometric methods of analysis have shown that, when DDT (formula IV) is injected into certain insects or absorbed by them, significant fractions become metabolized into some compound or compounds other than DDT. In the large milkweed bug *Oncopeltus fasciatus* the metabolites were not identified but appeared to be neither the ethylene derivative (V) nor the acetic acid derivative (VI)[1]. Sternburg, Kearns and Bruce[2] found a limited metabolism of DDT by their DDT-susceptible strain of housefly, *Musca domestica*, but found no evidence that the metabolite was either V or VI. They observed a greatly enhanced degree of metabolism in their DDT-resistant strain and concluded that the principal metabolite in this case was V, a relatively non-toxic compound. Perry and Hoskins[3], on the other hand, believed the metabolite in both their susceptible and resistant strains of housefly to be V. They found that the fractions of DDT metabolized in both strains were comparable, but were generally greater in surviving flies than in those which had succumbed.

$(BrC_6H_4)_2\,CH.CCl_3$ . . . . . (I) $(ClC_6H_4)_2CH.CCl_3$ . . (IV)
$(BrC_6H_4)_2\,C{:}CCl_2$ . . . . . (II) $(ClC_6H_4)_2C{:}CCl_2$ . . . (V)
$(BrC_6H_4)_2\,CH.COOH$ . . (III) $(ClC_6H_4)_2CH.COOH$ (VI)

Although an attractive possibility, the role of metabolism in the resistance of flies to DDT is not clear. The quantity of unchanged DDT recovered from surviving resistant flies was apparently, in many cases, more than enough to kill susceptible flies[2,3]. Moreover, as Ferguson and Kearns point out[1], the fact that lethal doses of DDT were almost completely metabolized by the milkweed bug within 90 min. of injection shows that even such rapid metabolism did not constitute an effective means of defence for this insect. The problem is further complicated by the fact that a resistant strain of fly obtained by selective breeding from the survivors of repeated DDT-treatments exhibited a comparable degree of resistance to certain insecticides other than DDT[4]; this suggests that their resistance might simply have been due to increased vigour rather than to some specific biochemical defence mechanism.

The insecticidal properties of the bromine analogue of DDT (I) are similar to those of normal DDT (IV), and there is no reason for believing that the insect metabolism of these compounds would differ fundamentally. The penetration and metabolism of (I) by susceptible and resistant strains of the housefly *Musca domestica* were therefore studied by labelling it with radioactive bromine-82. 1 µl. of acetone containing 2 µgm. of the radioactive bromine analogue (I*) was applied to the dorsal surface of the thorax of each of groups of five susceptible adults while under light cyclopropane anæsthesia. 50 µgm. of (I*) was similarly applied to each of groups of five adults from the strain resistant to normal DDT. The ratio of the doses applied to each strain was of the same order as the ratio of the median lethal doses of DDT. The treated groups were then transferred to loosely plugged test-tubes and observed. At intervals, groups of flies were removed. The fraction of (I*) unabsorbed and easily removed by briefly rinsing the fly in acetone, the fraction absorbed and the fraction lost to the tube by contact or through excretion were determined radiometrically.

After 5 hr. the susceptible and resistant flies had absorbed respectively 29 per cent and 5 per cent of the total weights of (I*) applied. At this time there was a sharp decrease in the rate of uptake, so that after 48 hr. the susceptible and resistant flies had respectively absorbed 50 per cent and 6 per cent of the total weights of (I*) applied. In neither case was the decrease in rate of uptake after 5 hr. apparently associated with any particular stage of paralysis (cf. Sternburg *et al.*[2]). It is significant, however, that in a single experiment when 2 µgm. of (I*) was applied to each of several resistant flies, the mean uptake after 24 hr. was the same as that for the susceptible

flies (40 per cent). The DDT-resistant flies were observed to be similarly resistant to the bromine analogue (I); but their resistance was not therefore associated with decreased absorption of the applied insecticide.

About 0·6 μl. of acetone containing 0·6 μgm. of (I*) was injected into each of groups of five susceptible and five resistant adult females. Injection was made dorsally into the thorax while the fly was under light cyclopropane anæsthesia. The injected dose was twice the L.D. 50 for DDT injected into a susceptible fly. Despite various precautions and despite the use of a precision micrometer-controlled syringe, the actual weights of (I*) injected, as determined radiometrically, varied considerably from fly to fly. The resistant flies of one group were killed by immersion in water at 90° C. for 60 sec. before injection. Another group of resistant flies was disintegrated in a pestle and mortar before adding the insecticide. In another group the solution for injection contained the pyrethrin synergist piperonyl cyclonene at the rate of 1 per cent (w/v) of solution. Finally, 50 μgm. of (I*) was applied topically to each of a group of resistant flies as in the penetration experiments.

After 0, 5 and 24 hr., groups of flies were macerated with anhydrous sodium sulphate and dilute sulphuric acid and the macerate extracted once at room temperature with a large excess of diethyl ether. About 95 per cent of the injected activity was recovered in the ethereal layers. The ether extract was then concentrated in a warm air stream, and aliquots roughly equivalent to one fly were examined by the radioactive tracer-chromatography technique described in an earlier communication[4]. Control runs indicated that under the experimental conditions (I*), (II*) or (III*) could be estimated to within about 5 per cent. Metabolism was observed only in the resistant flies. 23 per cent of the total weight of (I*) injected was recovered as the ethylene derivative (II*) after 5 hr. 57 per cent was recovered as (II*) after 24 hr. There was no evidence of the presence of the acetic acid derivative (III*) or of any metabolite of R_F value sufficiently different from that of (I) or (II). In the experiment in which (I*) was applied topically, 8·7 per cent of the weight of (I*) absorbed was recovered as (II*) after 24 hr. No evidence of metabolism was found in the resistant flies which had been killed by heating or by disintegration before injection. The presence of piperonyl cyclonene appeared completely to inhibit the metabolic dehydrohalogenation (cf. Perry and Hoskins[3]).

These results suggest that the metabolism is enzymic in nature and that the enzyme system is either destroyed or becomes inaccessible on disintegration of the tissue. The metabolism appears to be insufficiently rapid to account for the successful resistance of the flies used in these experiments; alternatively, only a small fraction of the applied insecticide is involved at the site of action; but it is this fraction which is metabolized (cf. Ferguson and Kearns[1]). It seemed possible that the mere presence of (II) might account for the observed resistance, for example, by blocking the site of action. Experiments were made, therefore, in which mixtures of (I) and (II) were injected into, or applied to, susceptible flies. No evidence of resistance was observed.

It is planned to describe more fully this and work proceeding elsewhere. We wish to thank Dr. J. R. Busvine and Miss C. M. Harrison, of the London School of Hygiene and Tropical Medicine, for gifts of pupæ from their DDT-susceptible and DDT-resistant strains of housefly, and for supplying data on the toxicity of normal DDT to these strains. This note is published by permission of the Department of Scientific and Industrial Research. [Sept. 28.

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MODERN TRENDS IN EDUCATION

IN his Clayton Memorial Lecture to the Manchester Literary and Philosophical Society, the Right Hon. R. A. Butler stated that the raising of the school-leaving age to fifteen has resulted in valuable worthwhile courses in up-to-date secondary modern schools, but that limited success has been achieved in all-age unreorganized schools. The Education Act can never be properly interpreted until reorganization along the lines advocated by the Hadow Committee is complete, and in 1947 there were still 8,014 unreorganized schools; one-fifth of the young people in Britain of more than fourteen years of age are still not provided for in secondary modern schools. In the primary schools, too, it has been difficult to improve standards because of the size of classes. In 1947 there were still 3,425 pupils in primary classes of more than forty; in these circumstances the teacher, Mr. Butler declared, is more a circus master than a prophet, and standards are bound to deteriorate.

Mr. Butler also showed that while the percentage of passes for the Higher School Certificate has remained constant at about 70 per cent over the past ten years, the number of students taking the examination in 1948 was more than twice the number taking the Higher School Certificate examination in 1938.

Of the general standards in schools, Mr. Butler suggested that in crowded schools pupils have not yet caught up the two-year backwardness which was the feature of the war period; in these schools pupils are still a year behind normal. In well-staffed schools with the best conditions, standards are up to the level of average times of peace. Newer methods of teaching have helped where teachers are competent to carry them out.

But the main danger which besets individual attainment of all-round excellence arises from undue specialization. It has always been a feature of the English tradition that the pupil is given a general background and that the faculties are developed in the broadest possible manner. Unfortunately to-day, when schools are apt to turn themselves into factories, no time is left for general study. Mr. Butler emphasized that he could not over-stress the wisdom of the words in the report on post-war education published in 1944 by a committee of the British Association which suggested that the sixth-form pupil, after devoting half his classwork and more of his private time to his speciality, should "pursue four general courses, covering respectively the humanities, the social sciences, the physical sciences, and the biological sciences, affording a connected and complete, if not profound, view of the whole of civilization. English expression, a modern language, and some-

times mathematics might also be included in this programme."

Although agreeing with the decision that bright pupils may not take their School Certificates before they are sixteen, Mr. Butler believes that the education authorities will move, or may be led to move, towards the decision whereby people should take their real examination of quality when they are seventeen. Before that age there would have to be examinations, but they should be of the "test of attainment" type based partly upon internal record. Standards, however, cannot be maintained through the examination system. Standards can be restored only by re-establishing the one vital link in education, and that is the relationship between teacher and taught. This will be achieved by a restoration of liberty of interpretation to the schools of Britain and their masters.

T. H. Hawkins

JUAN DE LA CIERVA FOUNDATION FOR TECHNICAL RESEARCH, SPAIN

An illustrated brochure describing the origin, aims and organisation of the Juan de la Cierva Foundation for Technical Research* which under the Higher Council for Scientific Research, created by the law of November 24, 1939, is responsible for all scientific work in Spain of a technical and industrial character, gives a fairly comprehensive picture of the organisation in Spain of scientific and industrial research. The Technical Advisory Council, which is the chief technical advisory organ of the governing body, is assisted by various technical committees which advise on the planning and development of any specific research activity.

Research work is carried out in a number of dependent institutes which investigate technical problems in a specific branch of applied science. These institutes include the Leonardo Torres Queredo Institute for Scientific Apparatus, the Institute for Technical Research on Building and Cement, the National Institute for Fuel Research, the Institute for Research on Fats, Oils and Related Products, the National Institute for Rationalization, the Welding Institute, the Iron and Steel Institute and the Institute of Electronics. The Foundation has also established a Department of Industrial Fermentation in the Institute of Microbiology, the Plastics Section of the Alonso Barba Chemical Institute, and the Section of Marine Biology in the Institute of Applied Biology, Barcelona. Research is also conducted by agreement with the Foundation in a number of independent institutions, such as the Institute for Technical Research, Barcelona, the Spanish Electro-Technical Association, the Laffon-Selgas Laboratory for Electrical-Acoustical Research, the Institute for Experimental Research in Forestry, the National Institute for Technical Aeronautics and the Cabro Sotelo Research Centre for Synthetic Fuels and Lubricating Oils.

Other institutions like the Alonso de Santa Cruz Institute of Physics, the Institute of Entomology, the Antonio de G. Rocasolano Institute of Physical Chemistry, the Daza de Valdés Optical Institute and the Institute for Soil Research, as well as the Universities of Madrid, Barcelona, Seville, Granada, Orviedo, and Valencia, are collaborating with the Foundation, while close liaison is fostered between the research centres of the Foundation and industry. The Foundation also seeks to encourage the training of research workers as well as the interchange of workers and of publications with foreign technical institutions. Brief notes on the work carried out by the institutes and research centres of the Foundation are included.

* Juan de la Cierva Foundation for Technical Research: its Organization and Development. Pp. 40. (Madrid: Juan de la Cierva Foundation for Technical Research, 1950.)

THE UNIT OF HEAT

In 1948 the International Unions of Chemistry and of Physics, and the International Conference of Weights and Measures, agreed to adopt the joule as the unit of heat in place of the calorie[1]. A memorandum on this subject was recently prepared by Sir Charles Darwin, chairman of the Symbols Committee of the Royal Society. After careful consideration of this memorandum, the Council of the Royal Society recommended that, in future, in the Society's publications, all quantities of heat and related concepts such as specific heat, entropy, etc., should be expressed both in joules and in calories. To facilitate this, the Society has issued a pamphlet in which the text of Sir Charles's memorandum and the Council's recommendations, tables of conversion factors from various calories and British thermal units to joules, together with examples of their use in textual, tabular and diagrammatic matter, are printed. No indication is given, however, as to how these factors have been determined; but it is presumed that they are in accordance with the best available experimental data.

It is made clear in the memorandum that, in accordance with the statement of the First Law of Thermodynamics that heat is energy, the joule, of 10^7 ergs, is the basic unit. This alone would not necessitate its use in actual practice; but it is well known that the several calories which are used are all different in value and that calorimetric work of high precision is invariably done electrically, involving electrical units which give results directly in joules to a high order of accuracy. Although the joule is theoretically the correct unit, it must be admitted that in the past nearly all work has been expressed in calories, and, doubtless, heat quantities expressed solely in joules may be unfamiliar to many men of science. For this reason, and in order to give prominence to the joule, it is recommended in the pamphlet that both the joule value and, in parentheses, the equivalent value in calories be quoted. This is similar to the practice recently advocated of giving metric equivalents to British mechanical units when the latter are used. It is strange, however, to find that the textual example shown in the pamphlet uses the reverse order to that recommended, the heat of combustion of carbon monoxide in oxygen being given in k.cal. per mole and the equivalent joule value in parentheses.

The replacement of the calorie by the joule is intended only for strictly scientific work, and the hope is expressed that, by the publication by the Royal Society of this pamphlet, the practice advocated by the Council of the Royal Society will be recommended and followed by other scientific bodies.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Vertical Distribution of Atmospheric Humidity near the Ground

PARTLY as an investigation in pure meteorology and partly as a study of the effects of air temperature and humidity on the propagation of very short-wave radio transmissions, autographic records of the temperature and humidity of the air at heights of 1, 15, 47 and 107 m. have been maintained at Rye (Sussex) during the three years July 1945 to June 1948. The station is located on flat marshland, and is about 5 km. from the sea. The temperature and humidity measuring elements were continuously aspirated.

The main features of the temperature records resemble those found elsewhere, for example, at Porton[1] and Leafield[2].

The humidity records are believed to provide information of a kind not hitherto available concerning

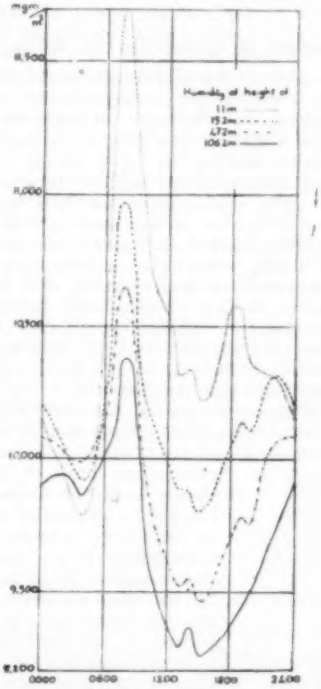

Fig. 1. Diurnal variation of absolute humidity during August at four heights

the vertical distribution of water vapour in the lowest 100 m. of the atmosphere, and its variation with time. The data, though not necessarily representative in detail of other localities, may be of interest for purposes other than those which gave rise to the investigation.

During the winter, the absolute humidity usually follows a diurnal variation with a maximum around noon at all heights, as might be expected.

In summer, however, the regime is quite different. Fig. 1 shows the average variation of absolute humidity throughout the day in August at each of

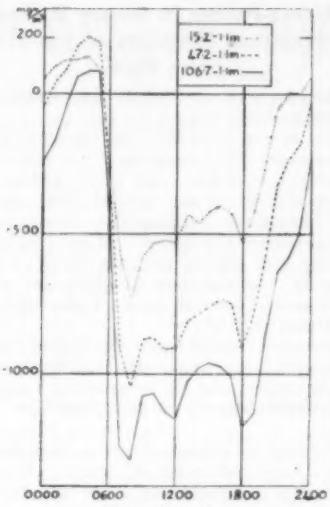

Fig. 2. Diurnal variation of absolute humidity differences during August

the four levels. The prominent peak maximum at about 0800 G.M.T., decreasing in magnitude with height, indicates the upward diffusion—by restricted atmospheric turbulence in the hours following sunrise—of surface-evaporated moisture. As the convective turbulence increases, moisture is diffused through a much deeper layer of air, and the absolute humidity in the lowest levels consequently decreases to a minimum in the afternoon. This morning maximum and afternoon minimum are characteristic of the summer months—April to September.

The effect of cloud upon the diurnal variation of absolute humidity is pronounced. On cloudy days in summer the amplitude of the diurnal variation is reduced to about half its value on clear days, and the time of occurrence of the maximum is delayed until late afternoon or early evening, instead of taking place in the early forenoon as on sunny days.

The mean differences between the absolute humidity at each of the three upper levels and the lowest level are illustrated in Fig. 2 for the month of August. The outstanding feature is the large decrease of absolute humidity upwards during the day. At night the difference in humidity becomes smaller and of opposite sign. This form of variation is broadly typical of that for other months.

The diurnal range of humidity gradient in winter is naturally much smaller, the value for February being about one-fifth of that for August. In nearly all months the nocturnal inversion of the day-time gradient extends to a height between 15 and 47 m., and in some months to beyond 107 m. The inversion is more pronounced on clear nights and less pronounced or non-existent on overcast nights.

It is proposed to publish shortly the detailed results of the investigation, and also the mean values of the 'modified refractive index' (as used in radio propagation work) computed from the temperature and humidity records.

N. K. JOHNSON

Meteorological Office, London. Oct. 11.

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New Sigma-Phases in Binary Alloys of the Transition Elements of the First Long Period

The structure of the brittle intermediate σ-phase in the system iron–chromium has not yet been determined; but isomorphous phases have been found in the systems iron–vanadium[1], cobalt–chromium[2] and iron–molybdenum[3]. All these phases occur at or near to the equiatomic composition, and this has led K. W. Andrews[4] to suggest that they are connected with superlattice formation. Recent work in this Laboratory has led to the discovery of four new σ-phases the compositions of which are of interest. The existence of two of these phases was predicted by Beck and Manly[5].

(1) *Chromium–manganese.* The intermediate phase in this system, previously denoted θ[6], has a typical σ-phase structure, and its composition range extends from approximately 72 to 83 atomic per cent manganese.

(2) *Vanadium–manganese.* The equiatomic alloy has a body-centred cubic structure; but an alloy containing 24·3 atomic per cent vanadium gave a typical σ-phase powder pattern though the microstructure was not homogeneous.

(3) *Vanadium–cobalt.* An alloy containing 50·5 atomic per cent vanadium has a σ-phase structure. This is consistent with the results of Köster and Lang[7] for the ternary system iron–cobalt–vanadium.

(4) *Vanadium–nickel.* An alloy containing 55 atomic per cent vanadium has the σ-phase structure; and this phase extends from about 55 to more than 65 atomic per cent of vanadium, and is probably stable up to the solidus.

The interplanar spacings for the vanadium σ-phases are slightly greater than those for the chromium σ-phases, as would be expected from the known atomic diameters. It is found that a single multiplication factor enables all the interplanar spacings of any one σ-phase to be converted into those of another. The multiplication factors necessary to make the observed d-values equal to those for the chromium–manganese phase are shown in the accompanying table, and the agreement is exact within the limits of experimental error.

System	Cr-Mn	Cr-Fe	Cr-Co	V-Mn	V-Fe	V-Co	V-Ni
Composition of the alloy	Mn 75·5% Cr 24·5%	—	—	Mn 75·7% V 24·3%	Fe 52% V 48%	Co 49·5% V 50·5%	Ni 45% V 55%
Multiplication factor	1	1·002	1·012	0·9935	0·9908	0·9984	0·9930

The above results show that the formation of σ-phases is not connected with an equiatomic superlattice, and support the suggestion of Sully and Heal[8] that σ-phases are electron compounds. We have not been able to obtain a σ-phase in vanadium–chromium alloys, and the present results therefore suggest that, in binary alloys of the First Long Period, σ-phases are found only in alloys of vanadium with elements from manganese to nickel, and in alloys of chromium with elements from manganese to cobalt. Bradley and Goldschmidt[9] state that the σ-phase structure corresponds to a distorted body-centred cube, and it is interesting to note that the phase apparently always occurs in equilibrium with a solid solution in the body-centred cubic metals chromium and vanadium.

Note added in proof. Our attention has been directed to a recent paper by Pietrokowsky and Duwez[10], who have also found σ-phases in vanadium–cobalt and vanadium–nickel alloys.

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Oct. 20.

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Formation of Order in the Alloy $CdMg_3$

The formation of a superlattice in the alloy $AuCu_3$ has been found to be accompanied by interesting X-ray diffraction effects[1,2]; superlattice lines on powder photographs gradually build up from the background, starting as very broad bands and sharpening gradually as perfect long-range order develops. This phenomenon has been shown, both theoretically[3] and by optical analogy[4], to be due to increase in the short-range order in the alloy.

So far, $AuCu_3$ seems to be the only alloy for which this phenomenon has been reported, with the possible exception of certain compositions in the copper–palladium system[5]. We have now found that similar effects occur for the alloy $CdMg_3$; this has a critical temperature of 160° C., and order develops fairly rapidly even at room temperature[6].

Since $CdMg_3$ is hexagonal, its powder photograph is much more complicated than that of $AuCu_3$, and when order develops many of the superlattice lines, particularly those at high angles, cannot easily be measured. The low-angle superlattice lines appear to be rather broader than the main-lattice lines; but those at higher angles, which should establish the effect with more certainty, are not easily seen in the background of the main-lattice lines.

This difficulty has been overcome by the use of single crystals. A single crystal was made by slowly cooling a small piece of the alloy from the melt at about 500° C. At these temperatures magnesium is readily attacked by both silica and air, and it was found necessary to place the alloy in an iron container in a silica tube containing argon at a low pressure.

X-ray oscillation photographs showed that the crystal was accompanied by one or two small satellites, but the superlattice spots could be clearly seen; and they were found to be definitely broader than the main-lattice spots. They sharpened appreciably when the crystal was left for several days at room temperature.

We propose to examine the shapes of the spots and to follow the changes in these shapes as order

develops. Comparison with the results for $AuCu_3$ may then provide more general evidence of the mechanism of superlattice formation than it has been possible to obtain from $AuCu_3$ only.

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Oct. 23.

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Two New Superconducting Elements

The low temperatures produced by adiabatic demagnetization of potassium chrome alum have been used to cool various pure metals to about 0·1° K.; a copper rod was used for providing thermal contact between the metal and the salt[1]. The occurrence of any superconducting transition in the metal was indicated by a change in the magnetic susceptibility of the metal in an alternating field. Superconductivity was observed in osmium and ruthenium with transition temperatures of 0·71° K. and 0·47° K. respectively. A superconducting transition in ruthenium at 2·04° K. was previously reported by McLennan, Allen and Wilhelm[2], but their specimen had a high residual resistance; and since no transition was observed by Meissner and Voigt[3] down to 1·2° K. in a specimen with much lower residual resistance, it is probable that the high transition temperature was associated with impurity. The critical magnetic fields were found to satisfy the relation $H_c = H_0 (1 - (T/T_c)^2)$; the values of H_0 and T_c are compared in the accompanying table with recent measurements by Goodman and Mendoza[4] on a number of other elements with low transition temperatures. The values for aluminium and zinc differ only slightly from those found by Daunt and Heer[5].

	T_c ° K.	H_0 gauss
Aluminium	1·197	106
Cadmium	0·560	29
Gallium	1·103	51
Zinc	0·905	53
Osmium	0·71	65
Ruthenium	0·47	46

The following elements were not superconducting down to the temperatures indicated: lithium (0·08° K.), sodium (0·09° K.), potassium (0·08° K.), barium (0·15° K.), yttrium (0·10° K.), cerium (0·25° K.), praseodymium (0·25° K.), neodymium (0·25° K.), manganese (0·15° K.), palladium (0·10° K.), iridium (0·10° K.), platinum (0·10° K.).

Before the discovery of superconductivity in uranium[6,7], rhenium[7], osmium and ruthenium, all the known superconductors were grouped together in two regions in the Periodic Table; it may be noted that these four elements occur in places between these regions, and the superconducting elements can no longer be regarded as so well localized in the periodic classification.

I am indebted to Prof. F. H. Spedding for the loan of pure specimens of yttrium, cerium, neodymium and praseodymium, and to Prof. E. Justi for the loan of one of the pure specimens of ruthenium used; his electrical measurements on this specimen[8] have shown that it has an even lower residual resistance than the specimen studied by Meissner and Voigt[3].

B. B. Goodman

Royal Society Mond Laboratory,
Cambridge.
Nov. 11.

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Heat Conductivity of Liquid Helium I

Some properties of liquid helium I undergo an anomalous change as the lambda-point is approached. The entropy begins to drop rapidly with falling temperature between 2·6 and 2·19° K.[1], and a similar drop in the same temperature region has recently been found in the viscosity[2]. The question therefore arose whether in the same temperature interval the heat conductivity will begin to rise to the anomalously high value found below the lambda-point. Such measurements have now been carried out and the result would seem to merit a preliminary communication. The experiments have been carried out on a vertical cylinder of liquid at the top of which heat was supplied. The heat was conducted downwards to a heat sink which could be maintained at a constant temperature. Two resistance thermometers of leaded brass were arranged at different heights within the cylinder and parallel to its base. The liquid was enclosed by a glass container in the form of a Dewar vessel.

The salient feature of the results is the absence of any appreciable rise in the heat conduction of helium I as the lambda-point is approached. Any measurement of the heat conductivity of helium I faces a number of fundamental difficulties due to the fact that its absolute value is very small, while the mobility of the liquid and its specific heat are high. Moreover, the heat conduction of any container material, even glass, far surpasses that of the liquid helium. Consequently, our results for the effective conductivity of the arrangement, in addition to being subject to a mean scatter of $\pm$ 6 per cent, contain an appreciable correction for the heat flow along the glass envelope. Accurate numerical values for the heat conductivity of helium I cannot be given until the heat conductivity of the particular glass used has been measured in the same temperature-range. Using the values available for another type of glass, we conclude that the heat conductivity of helium I varies roughly proportional to the absolute temperature, and that our absolute value is of the same order of magnitude as the single determination by Keesom and Keesom[3] at 3·3° K.

R. Bowers
K. Mendelssohn

Clarendon Laboratory,
Oxford. Nov. 8.

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Experimental Determination of the Life-times of Atomic Resonance States

Previous experimental work on the measurement of the life-times of atomic energy states has been subject to error mainly due to the inaccuracy of vapour pressure data. A magnetic rotation method devised by Weingeroff[1] which eliminates the vapour pressure in the final expression for the life-time has apparently been overlooked. This method has recently been employed here[2] for the measurement of the life-times of certain atomic resonance states; a detailed account of the method will be given in a later paper; but it was felt that the following results would be of interest at the present time.

Atom	Transition	Wave-length	Life-time (sec.)
Na	3^2S–3^2P	5896, 5890 A.	$1{\cdot}61 \pm 0{\cdot}06 \times 10^{-8}$
K	4^2S–4^2P	7699, 7665	$2{\cdot}71 \pm 0{\cdot}09 \times 10^{-8}$
Rb	5^2S–5^2P	7947, 7800	$2{\cdot}81 \pm 0{\cdot}09 \times 10^{-8}$
Tl	$6^2P_{3/2}$–$7^2S_{1/2}$	5350	$1{\cdot}43 \pm 0{\cdot}05 \times 10^{-8}$

Further work is progressing with the view of adapting the method to molecular transitions, and the results will be reported at a later date.

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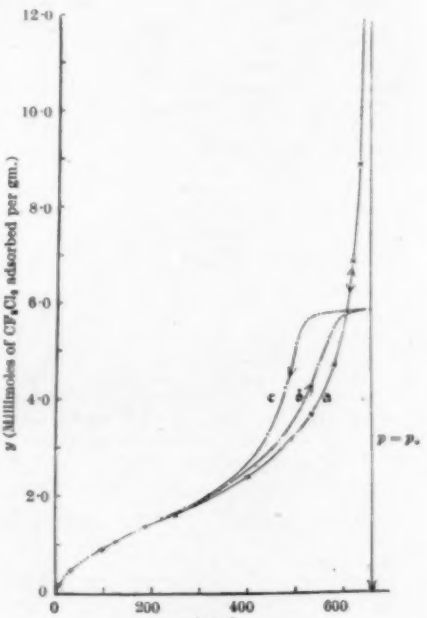
Role of Capillary Condensation in Physical Adsorption

The study of physical adsorption in the past decade has been dominated by the theory of multilayer formation put forward by Brunauer, Emmett and Teller[1,2]. Despite quantitative limitations, the theory explains the sigmoid shape of isotherms obtained normally for adsorption on free surfaces. In the case of porous solids, it suggested that pore diameters furnish an upper limit (n) to the number of multilayers, and derived appropriate n-limited equations. Modified forms of these equations were later suggested by Brunauer, Deming, Deming and Teller[3], by Anderson[4,5], and by Pickett[6]. The fundamental point of all of these equations is that a pore becomes filled by building up n layers of adsorbed molecules, thereby obviating the need for postulating capillary condensation.

It has become increasingly clear that capillary condensation cannot be dismissed as easily as this. Indeed, there is strong evidence that capillary condensation takes place in addition to multilayer formation. The point is one which can readily be tested. Suppose we compare isotherms for a loose powder with a surface of more than 100 m.²/gm. and for the same powder compressed to a plug of fairly low porosity. On the theory of multilayers, the plug would show progressively lower adsorption than the powder as relative pressure increases, since surface properties are unchanged, and the only difference is that n is restricted from infinity to a small finite value.

If, however, capillary condensation is possible, the reverse is true, since an increasing proportion of pores becomes filled by this process with increase of pressure. We thus expect the isotherm for the plug to rise above the isotherm for the free powder, though, of course, at very high relative pressures the pore-space becomes completely filled, and adsorption on the loose powder, being unlimited, then becomes greater.

By a series of experiments along these lines we have decisively confirmed the importance of capillary condensation. A typical experiment is shown in the accompanying graph. Curve (*a*) is for adsorption of CF_3Cl_3 on Linde silica as a loose powder at $-33{\cdot}1°$ C. (saturation vapour pressure, $p_0 = 659$ mm.). By adsorption of nitrogen, the surface was found to be 300 m.²/gm. Desorption gave points on the same curve. Curves (*b*) and (*c*) are adsorption and desorption branches for the same powder compressed to a porosity of 0·506. At low pressures, neither multilayer formation nor condensation is important, so that both plug and powder give identical results within experimental errors. At higher pressures, adsorption on the plug takes place much more rapidly. Finally, a limit of $y = 5{\cdot}84$ millimoles/gm. is approached.



Adsorption of CF_3Cl_3 at $-33{\cdot}1°$ C. on Linde silicon: ×—×—, loose powder; —.—., plug ($\epsilon = 0{\cdot}506$)

The calculated limit, assuming the density of liquid CF_3Cl_3 at $-33{\cdot}1°$ C., was $y = 5{\cdot}72$. It is not likely that the difference is due to experimental errors, so that it is probably due either to a difference in density between adsorbate and bulk liquid, or to a reversible swelling of the plug during adsorption. On desorption, a well-marked hysteresis loop is observed, confirming that this is associated with capillary condensation. It may be noted that, about midway along the desorption branch, it became necessary to leave the sample overnight. No change took place in this time, indicating that the cause of the difference between the adsorption and desorption branches is certainly not due to slow rates of equilibration.

We wish to thank the South African Council for Scientific and Industrial Research for permission to publish this note.

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Ventricular Nerve Cells in Mammals

It is widely believed that, in mammals generally, cardiac nerve cells are limited to the atria, extending at the most as far distally as the base of the ventricles near the atrioventricular sulcus. We have examined histologically the hearts of representatives of a number of orders of mammals, namely, Monotremes, Marsupials, Insectivora, Rodentia, Carnivora, Cetacea, Artiodactyla, Perissodactyla, Chiroptera, Menotyphla and Primates. In most of these, no nerve cells were found in the epicardium, endocardium or myocardium of the ventricles. Only in Cetacea and Artiodactyla (see later) are ventricular nerve cells abundant; literally, many thousands extend widely over both ventricles in the epicardium, and numerous nerve cells accompany the atrioventricular bundle and its right and left limbs in the ventricular endocardium, but are not found elsewhere in the endocardium or in the myocardium. In Perissodactyla, no nerve cells were found in the ventricles; the difference between Artiodactyla and Perissodactyla in this respect lends support to the modern tendency (based on other morphological differences) to discontinue the use of the term 'Ungulates' to include both these groups, and to raise both to equivalent ordinal rank. Among Artiodactyla, the Ruminants show a much more extensive distribution of ventricular nerve cells than do the Non-ruminants; in this respect the Cetacea resemble the Ruminants, a feature that supports other morphological evidence of affinity between these two groups.

Previous observers are agreed that in the atria of mammals the great majority of nerve cells are multipolar. Our study reveals that in the ventricles of Cetacea and Artiodactyla most of the nerve cells in the epicardium are bipolar or unipolar, multipolar cells comprising a minority; by contrast, the majority of cells related to the atrioventricular bundle and its limbs are multipolar, few being bipolar or unipolar. It is generally believed that all nerve cells in the heart (as in other viscera) are efferent parasympathetic in nature. Two observations have led us to wonder whether the bipolar or unipolar cells might be sensory (afferent) and the multipolar cells efferent; namely, (1) in many cases we noted that the single process of a unipolar cell divided into two some distance from the cell body, such cells thus resembling the pseudo-unipolar cells of the spinal and cranial nerve ganglia; and (2) whereas we observed the endings (synapses) of nerve fibres in relation to the cell bodies and processes of the multipolar cells, we have not found any nerve endings about the bipolar and unipolar cells. We have some degeneration experiments in hand in the hope of obtaining further information on this question.

Osmic preparations showed the presence of numerous medullated nerve fibres, of various sizes and thickness of myelin sheath, in the ventricular epicardium and endocardium. In neither situation were elaborate nerve endings seen, the nerves ending by simply coming to an end or by having simple bulb-like enlargements at their extremities. In relation to the ventricular cardiac muscle fibres, fine nerves end by forming spirals around individual muscle fibres; they do not penetrate into the muscle fibres, and we have failed to find anything resembling muscle spindles of voluntary muscle (which are very elaborate neuromuscular complexes).

We submit that the nerve spirals around the myocardial fibres are probably sensory in nature and could well be the anatomical arrangement that could serve as stretch receptors in the ventricular myocardium. We have not found any nerve endings that could be interpreted on morphological grounds to be motor endings in relation to the cardiac muscle fibres. In the case of the Purkinje fibres of the atrioventricular bundle and its limbs, however, we have observed two types of nerve endings: (1) a fine plexus on the surface of the Purkinje fibres, which may be sensory in nature; and (2) a series of simple knob-like endings on the surface of the Purkinje fibres, which we suggest are motor endings. Neither the endings related to the myocardial fibres, nor those related to the Purkinje fibres, are extremely numerous, and it appears to us that their relative paucity may be correlated with the syncytial nature of the heart musculature.

A full account of this work, with a survey of the extensive literature, will be published elsewhere.

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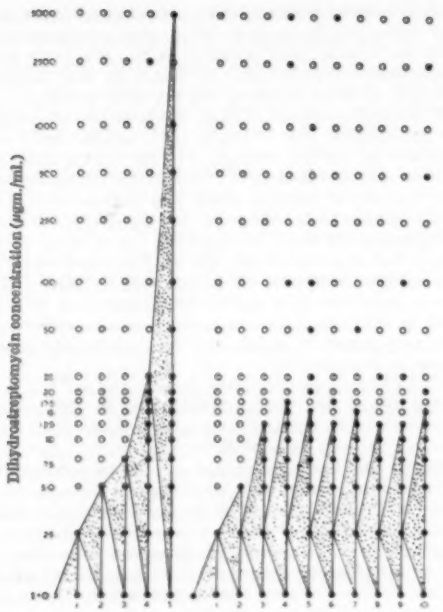
Development of Resistance to Dihydrostreptomycin by *Bacterium coli*

The development of populations of bacteria showing increased resistance to drugs is usually assumed to be the result of: (1) a continuous increase in resistance as a result of interaction between drug and cell[1], that is, adaptation, or (2) a discontinuous increase due to selection of a few resistant cells either already present[2] or induced by the drug[3], that is, spontaneous or induced mutation.

Our experiments indicate that with regard to dihydrostreptomycin both these processes may be involved. By exposing a strain of *Bacterium coli* to a range of concentrations of the drug in a glucose synthetic medium (glucose 10 gm. (sterilized separately), KH_2PO_4 3 gm., K_2HPO_4 6 gm., NH_4Cl 1 gm., $MgSO_4.7H_2O$ 25 mgm., $FeSO_4.7H_2O$ 2·5 mgm., distilled water 1 litre) a striking and consistent pattern has been observed.

The experiments were of two types: (*a*) 'progressive training' by using the organisms growing in the highest concentration of dihydrostreptomycin, excluding 'wild plus' growths (see below) as the



(a) Progressive training; (b) repetitive training. ●—●—, Growth O—O—, no growth

inoculum for the next titration; (*b*) 'repetitive training' by subculturing repeatedly from a low concentration of dihydrostreptomycin (2·5 μgm./ml.) and determining the level of resistance at each subculture. A typical pair of experiments is shown in the accompanying diagram, which illustrates results obtained by progressive and repetitive training. Each titration included the range of concentrations indicated in the diagram, and the source of inoculum for any particular titration is shown by lines joining this titration with a tube from the previous set.

All titrations were incubated for four days at 37° C. and visible turbidities observed each day. The final result for any titration was taken from the four-day reading, but subcultures for subsequent titrations were made on the day on which heavy turbidity was first observed. Thus in repetitive training experiments, the subcultures from 2·5 μgm./ml. were always made after 24 hr. incubation at 37° C., but in progressive training it was sometimes necessary to subculture more than once if the end point rose with further incubation up to the fourth day. This method was found necessary, since once maximum population is reached in this medium further incubation markedly decreases the viable count.

End-points of growth, that is, concentrations up to and including those at which growth has occurred without exception, for example, titration 4 (*a*), 25 μgm./ml., have been observed at all dihydrostreptomycin levels from 2·5 to 50 μgm./ml.; but no end-points are obtained between 50 and 5,000 μgm./ml. Resistance above 50 μgm./ml., therefore, indicates resistance to at least 5,000 μgm./ml. This is supported by the observation that cells from any tube containing more than 50 μgm./ml. dihydrostreptomycin, when further titrated, grow at all concentrations up to and including 5,000 μgm./ml. Recent experiments have shown that these cells are resistant to at least 20,000 μgm./ml. Examination of the colony types on dihydrostreptomycin-free media shows that the resistant cells grow more slowly than the sensitive types and produce smaller colonies after 24 hr. at 37° C. The random growths ('wild plus') shown in the diagram, for example, titration 4 (*a*), 2,500 μgm./ml., consist of cells which are resistant to all concentrations of the drug and give rise to the small colonies mentioned above. After two or three titrations a mixture of small and large colonies is often obtained from cultures growing in concentrations of less than 50 μgm./ml., excluding 'wild plus' growths. We have observed that the appearance of such mixed cultures in training experiments heralds the abrupt increase in resistance.

It appears reasonable from a result of this type to postulate that a relatively slight increase in resistance (up to tenfold) is due to adaptation initiated by exposure of the cells to low concentrations of the drug, and that the degree of adaptation can exceed that required for growth at the concentrations to which the cells are exposed (see diagram, *b*). Highly resistant cells appear in sufficient numbers in progressive training experiments, such as that depicted in the diagram (*a*), to give rise to growth in all concentrations of dihydrostreptomycin tested. These cells also appear in the populations obtained by repetitive training but are not favoured by a selective process.

The results clearly show that a high level of resistance to dihydrostreptomycin can be reached from a very low one in a single 'step', indicating a single mutation, either occurring spontaneously, or induced by the drug itself. The results shown in the diagram (*b*) would seem to favour the latter hypothesis, since the possibility of selection of a rare mutant by the suppression of the sensitive cells is excluded. However, studies on the relative growth-rates of resistant and sensitive cells at low concentrations of dihydrostreptomycin may obviate the necessity for such an explanation.

We wish to thank Prof. S. D. Rubbo for his advice, Miss J. Poolman for valuable technical assistance and the National Health and Medical Research Council for a grant (M. I. G.) supporting this work.

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Sparing Action of Fats and Pyruvate in the Blood of Rats in Avitaminosis B_1

It is now generally accepted, especially through the work of Evans and Lepkovsky[1], that a diet of carbohydrates accelerates the appearance of the symptoms of polineuritis in animals suffering from avitaminosis B_1, whereas an excess of fats delays it, revealing an effect which is considered as a sparing action. This has been confirmed by many other workers.

Recently, the problem has been studied by Krider and Guerrant[2], who emphasize that the concentration

PYRUVIC ACID (MGM. PER 100 GM. OF BLOOD)

Controls					Avitaminosis				
Time of introduction of the oil (1 ml.)									
Basal amounts	1 hr.	2 hr.	4 hr.	6 hr.	Basal amounts	1 hr.	2 hr.	4 hr.	6 hr.
0·94	0·97	1·18	1·11	1·20	2·70	2·40	1·93	1·14	0·94
1·07				0·68	2·29	1·15	1·35	1·28	0·89
1·65				0·75	1·83	1·27	2·01	2·75	1·07
0·64				0·79	4·05				1·31
0·97				0·98	1·29				1·19
1·07					1·42				1·09
1·22					1·89				0·72
0·93					1·80				0·44
0·99					2·27				0·47
0·70					1·97				
					1·28				
					1·51				
					2·86				
Av. 1·01 ± 0·28				0·89 ± 0·21	2·10 ± 0·77				0·90 ± 0·3

of aneurin in the hearts of rats getting more than 2 μgm. of aneurin a day increases with the fat content of the diet; but they also point out that the increase following the addition of 10 per cent of fats is larger than that obtained by administering 20 per cent of fats. They believe that "the data do not necessarily indicate that dietary fat exerts a sparing action on thiamine requirements". Gruber[3] states precisely the meaning to be given to the expression 'sparing action of fat vitamin B_1', indicating that it is to be interpreted as due to a decreased call for vitamin in metabolic processes. In fact, some of Gruber's researches (pigeons) show that the increased metabolism of carbohydrates induced through a larger introduction of these substances causes a quicker disappearance of aneurin pyrophosphate from the tissues.

We have studied the effects of fats from another point of view, namely, that of the pyruvic acid content of the blood. The work is based on the fact that, through the fundamental researches by Peters[4,5] and his school, as well as those on man and animals by Lu[6], it can be considered as proved that close relations exist between avitaminosis B_1 and the accumulation of pyruvic acid both in poultices of tissues *in vitro* and in tissues and blood *in vivo*. Our present investigations are part of a larger group of researches, the aim of which is to study what influence the administration of carbohydrates (glucose), amino-acids and fats can have on the pyruvic acid of the blood of animals suffering from avitaminosis B_1.

Rats of the initial weight of 55–60 gm., kept on a synthetic diet deprived of vitamin B_1 (wheat starch 65 per cent, caseine deprived of fat and washed 18 per cent, olive oil 10 per cent, cod liver oil 2 per cent, Osborne and Mendel's saline mixture 5 per cent), with appropriate quantities of other vitamins belonging to group B (riboflavine, pyridoxine, niacine, pantothenic acid, biotin, inositol and choline), were used when the weight of the rats, after increasing during two to three weeks, came down again to a little more than the initial rate. Besides being controlled by their weight, the state of avitaminosis of these rats was checked by the amount of pyruvic acid in their blood.

The pyruvic acid was estimated by Lu's method as modified by Fornaroli[8]; blood was collected within 30 sec., and the blood withdrawn, collected on a little sodium fluoride, was immediately treated with freshly prepared 12 per cent trichloracetic acid.

In order to study the influence of fats on the pyruvic acid of the blood, 1 ml. of olive oil was introduced, by means of a sound, into the stomach of the animals suffering from avitaminosis which had been kept fasting for 12 hr. These animals were then sacrificed by decapitation, generally after 6 hr. In a limited number of cases they were sacrificed after 1, 2 or 4 hr.

The accompanying table shows the amount of pyruvic acid found in the blood of a series of rats.

The results clearly show that after 6 hr. from the introduction of the oil, the pyruvic acid in the blood of animals suffering from avitaminosis B_1 falls again to its normal amount. This decrease begins at the sixth hour from the introduction of the oil, showing that the effect takes place after absorption of the fat; in fact, after 6 hr., no significant quantity of oil was found in the stomach of the animals. A very small decrease, of which we are not yet sure and which requires further investigation, has also been noticed in normal rats 6 hr. after the administration of oil.

The exact return to the normal amounts of pyruvic acid in the blood of rats suffering from avitaminosis, after the administration of fat, seems clear evidence of the sparing action caused by fat. The organism finds itself with excess lipids and consequently metabolizes fats in preference to carbohydrates and proteins. As we have already shown, glucose and amino-acids administered to animals suffering from avitaminosis B_1 cause a noticeable increase of pyruvic acid in the blood.

The quick fall of pyruvic acid in the blood is in accordance with the interpretation of the sparing action of fats, showing that aneurin does not share in the fermentative systems involved in the metabolism of fats[9].

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Dihydroxyanthranilic Acid as a Precursor of Nicotinic Acid

A MIXTURE of 400 mgm. of *o*-aminoveratric acid (prepared by the method of Pschorr and Sumuleanu[1]), 100 mgm. of red phosphorus and 8 ml. of hydriodic acid (sp. gr. 1·7) was heated in a sealed tube at 100° for eight hours and then at 105° for two hours. The hydriodic acid salt of 2-amino-3,4-dihydroxybenzoic acid crystallized on cooling. After filtration, this product was recrystallized from a small amount of hydriodic acid containing water and obtained as macroscopic prismatic needles (m.p. 220°; found: N, 4·29; $C_7H_8O_4NI$ requires N, 4·71 per cent). The hydriodide of dioxyanthranilic acid was easily

dissociated by washing with a larger amount of water, and the free acid was recrystallized from alcohol (m.p. 174°; found: N, 8·05; $C_7H_7O_4N$ requires N, 8·29 per cent).

8 gm. of liver slices of cattle, pigs and horses prepared immediately after killing was incubated with the mixture of 5 mgm. of L-tryptophane or of another substance (in the case of other substrates an equimolecular amount to tryptophane was weighed) in 3 ml. of physiological saline solution and 5 ml. of $M/15$ phosphate solution (pH 7·5) for 24 hr. Its nicotinic acid content was determined by the method of Swaminathan[2] and Kawashima[3] with bromcyan and aniline.

This chemical method is based upon the colour reaction of the anil which is formed by interaction between aniline and a carbonyl compound, a fission product of the pyridine ring with bromcyan. This colour reaction is so specific that in the case of α-substituted pyridine compounds, for example, quinolinic acid and pyridoxin, this colour reaction becomes negative. Accordingly, if a substance derived from tryptophane gives this colour reaction, the compound in question may be said to be nicotinic acid.

Table 1

pH	Increase of nicotinic acid (mgm.)			
	Horse liver		Cattle liver	
	Quinolinic acid	Tryptophane	Quinolinic acid	Tryptophane
6·0	0·24	0	0·13	0·09
7·5	0·35	0·14	0·53	0·56
8·1	0·24	0·12	0·17	0·13

Under our experimental conditions, the yield of nicotinic acid from tryptophane was greatest at pH 7·5, and to both sides from this pH the production of nicotinic acid rapidly decreased. The yield of nicotinic acid increased proportionately to the amount of substrate up to 2 mgm. of tryptophane; above this amount the increase of nicotinic acid is very small.

Table 2. Experiment with Cattle Liver

Substrate	Amount of substrate added (mgm.)	Increase of nicotinic acid (mgm.)
Tryptophane	5	0·30
Anthranilic acid	3·4	0
3-Hydroxyanthranilic acid	3·9	0·73
3,4-Dihydroxyanthranilic acid	4·2	0·73
Quinolinic acid	4·1	0·38
Control	0	0

All the results recorded in Tables 1, 2 and 3 were obtained in the hot summer season (July and August, 1950). In winter the yield of nicotinic acid produced by the liver enzyme from tryptophane seemed to be twice or three times as much.

Table 3. Experiment with Horse Liver

Substrate	Amount of substrate added (mgm.)	Increase of nicotinic acid (mgm.)
Tryptophane	5	0·14
Anthranilic acid	3·4	0
3-Hydroxyanthranilic acid	3·9	1·24
3,4-Dihydroxyanthranilic acid	4·2	1·04
Quinolinic acid	4·1	0·35
Control	0	0

Anthranilic acid, which was added to the cattle liver slices, did not produce nicotinic acid. 3-Hydroxyanthranilic acid and 3,4-dihydroxyanthranilic acid were also used. Both acids have almost the same ability to produce nicotinic acid, and the yield exceeded considerably that from tryptophane.

According to Henderson[4], rats excrete quinolinic acid in the urine after administration of a larger dose of tryptophane. In our own clinical investigations the quinolinic acid cured pellagra, though a much larger dose of it was necessary than of nicotinic acid.

However, the amount of nicotinic acid produced from quinolinic acid is less than from 3-hydroxyanthranilic acid and almost the same as that of tryptophane; and it is obvious that 3,4-dihydroxyanthranilic acid must be taken into consideration as one of the precursors of nicotinic acid.

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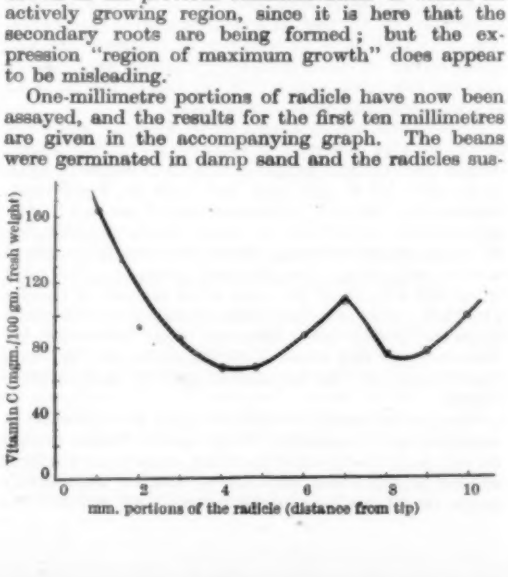
Distribution of Vitamin C in the Tip of the Broad Bean Radicle

It was stated in an earlier communication[1] that if 4-mm. portions of the broad bean radicle were assayed for vitamin C, the ninth portion from the tip contained an average of 112·96 mgm. of the vitamin per 100 gm. of fresh weight. This amount was thought to be present within the region of maximum growth. Following this statement, J. Read pointed out to us in a private communication that the accepted region of maximum growth occurs at a distance of 5–7 mm. from the tip. He suggested that analysis of one-millimetre portions should therefore be undertaken.

The rise in the vitamin C content of the radicle shown in the previous communication[1] is within an actively growing region, since it is here that the secondary roots are being formed; but the expression "region of maximum growth" does appear to be misleading.

One-millimetre portions of radicle have now been assayed, and the results for the first ten millimetres are given in the accompanying graph. The beans were germinated in damp sand and the radicles sus-



pended in aerated water in the dark. When the radicles were ten centimetres in length, one-millimetre portions were cut off and assayed for vitamin C using 2,6-dichlorophenolindophenol. The points shown in the graph represent means of forty-nine one-millimetre portions.

The graph shows a high concentration of vitamin C in the first portion. A fall in the vitamin concentration occurs in the second to the fourth portions, and this is followed by a rise in the seventh portion. Thus the region of maximum growth, as shown by Sachs's classical experiment, does contain a reasonably high quantity of the vitamin, as might be expected if vitamin C is of importance in growth.

We wish to thank the headmaster of this School, Mr. W. R. G. Bye, for his continued interest in the work, and Mr. D. T. Barnard for his assistance with the vitamin assays.

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Role of Glutaminase in the Production of Urinary Ammonia

If, as Van Slyke, Philips, Hamilton, Archibald, Futcher and Hiller[1] suggest, urinary ammonia is mainly produced in the kidney from glutamine, it is possible that changes which increase or decrease the amount of ammonia produced might increase or decrease the amount of renal glutaminase. Such adaptation, if it occurred, would support the view that glutaminase is in fact involved in the production of urinary ammonia.

This possibility was investigated by a quantitative study of L-glutaminase in the kidneys of rats rendered chronically acidotic or alkalotic. The animals were litter-mate female albino rats of the Wistar strain and weighed about 170 gm. at the beginning of the experiment. They were fed on a mixture of bread, casein, cane sugar, arachis oil, cod liver oil, dried yeast and salt mixture. They were divided into three groups, each of six animals, and were given to drink, *ad libitum*, either water or 0·05 *N* hydrochloric acid or 0·1 *N* sodium bicarbonate. At the end of three months, the average daily excretion per rat of ammonia (as ammonia-nitrogen) was 7·5, 13·8 and 2·9 mgm. respectively, while the average weight of the animals was still similar in the three groups.

The activity of glutaminase in each rat was then determined in the Warburg apparatus by the method of Krebs[2]. Slices of kidney (cortex and medulla) were incubated in the presence of 4 mgm. of L-glutamine for 30 min. and the ammonia produced estimated by a modification of the method of Van Slyke and Cullen[3]. The tissue slices used were dried and weighed at the end of the experiment. The ammonia produced in the control flasks (by kidney tissue in the absence of glutamine) was deducted from that produced by the same amount of tissue in the presence of glutamine.

Preliminary experiments had shown that there was no linear relationship between ammonia production and the amount of tissue. It was therefore decided to use four different weights of tissue from each animal. A curve was then constructed from the results with each animal, and from it was calculated the amounts of ammonia produced by four arbitrary dry weights of tissue: 6 mgm., 8 mgm., 10 mgm. and 12 mgm. The mean values for each group of animals, calculated in this way, are given in the accompanying table.

Activity of L-Glutaminase in Rat Kidney Slices

Mean intrapolated values ± S.E., from six rats in each group, expressed in μgm. ammonia-nitrogen produced in 30 min.

Dry wt. of tissue (mgm.)	Normal	Acidotic	Alkalotic
6	67 ± 2·8	125 ± 15·3	43 ± 4·1
8	87 ± 2·4	157 ± 17·5	66 ± 3·9
10	97 ± 3·0	181 ± 16·6	77 ± 4·2
12	101 ± 3·8	195 ± 15·9	81 ± 4·6

The differences between the means of any two groups are significant ($P < 0·01$).

The results show that acidosis produced an increase in glutaminase, whereas alkalosis produced a decrease in the enzyme. These results support the hypothesis that L-glutaminase is concerned in the production of urinary ammonia.

The findings reported here contradict those of Handler, Bernheim and Bernheim[4], who found no difference in ammonia produced from glutamine by kidney slices of normal, acidotic or alkalotic rats. Inspection of their results, however, reveals that not only did they use only one rat of each sort, but also that the ammonia produced in the Warburg apparatus represents about 90 per cent hydrolysis of the glutamine. It is clear that differences in enzyme activity might easily not be revealed under these conditions.

Further work is proceeding on the effect of acidosis and alkalosis on the metabolism by the kidney of other amino-acids. So far, it has been shown that renal deamination of L-aspartic acid is unaffected by changes in the excretion of urinary ammonia. It will be of particular interest to study the effect on amino-acids which are oxidized by L-amino-acid oxidase, since Lotspeich and Pitts[5] have shown that intravenous infusion of these increased the excretion of ammonia in acidotic dogs more than the infusion of amino-acids which are not oxidized by this enzyme.

We gratefully acknowledge financial support for this work from Messrs. Allen and Hanburys, Ltd., British Drug Houses, Ltd., and Messrs. H. W. Carter and Co., Ltd.

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Utilization of Vitamin A_1 by Freshwater Fish

Wald[1] has pointed out that freshwater fish contain vitamin A_2 whereas marine fish contain vitamin A_1. This was confirmed by Gillam[2] and Lederer *et al.*[3]. It is only migratory fish which contain a mixture of both vitamins A_1 and A_2.

Karrer *et al.*[4] suggested that vitamin A_2 is not utilized by mammals and may even be toxic to them.

Shantz *et al.*[5], however, have shown that rats, depleted of vitamin A_1, can utilize vitamin A_2, which can be recovered unchanged from the retina and the liver. Morton *et al.*, in 1947, have shown[6] that if retinene$_2$ is given to rats, it has vitamin A activity. It is first reduced to vitamin A_2 and is stored in the liver in the form of vitamin A_2 esters.

In the present work, vitamin A_1 was fed to freshwater fish, obtained from the River Nile. These fishes were tested and found to contain predominantly vitamin A_2. Vitamin A_1 was found to be stored in the liver, and no toxic effects were observed even after massive doses of vitamin A_1. Two species of Nile fishes were used. Of the first, *Clarias lazera*, fifteen fishes were first examined. The livers contained exclusively vitamin A_2, as shown by the ultra-violet absorption spectrum at 350 mμ (in petrol) and the antimony trichloride colour test at 693 mμ. The range of vitamin A_2 contents of the livers varied from 30 to 130 μgm. per gm. of fresh liver. Twelve fishes of nearly the same size were fed vitamin A_1 in oil and examined periodically.

In three of the fishes, the cod liver oil (potency 1,000 I.U. per gm.) was given by stomach tube, 1 ml. daily for six days. The livers were then removed, crushed with anhydrous sodium sulphate and sand and extracted with petroleum ether and examined spectroscopically. The presence of vitamin A_1 was proved by the antimony trichloride colour reaction at 617 mμ and the ultra-violet absorption spectrum at 328 mμ. The yield of vitamin A_1 was, however, very poor (about 5 per cent of the vitamin A_1 given). This may be due to regurgitation or excretion of unabsorbed oil.

In the other nine fishes, a vitamin-A_1 concentrate in oil, containing 10,000 I.U./gm., was administered by subcutaneous injection. Increasing doses up to 60,000 I.U. were given. A very good recovery of the vitamin A_1 was obtained in this experiment. The yield of vitamin A_1 amounted to 40 per cent of the amount ingested. It showed the typical spectroscopic characteristics of vitamin A_1, having a maximum absorption band at 328 mμ in the ultra-violet and a 617-mμ band in the antimony trichloride colour test.

Similar experiments were repeated on another species of Nile fish, namely, *Tilapia nilotica*, the results of which confirmed the previous findings. Three of these fishes were given 60,000 I.U. of vitamin A_1 and left for one month without showing any sign of toxic effects.

These experiments seem to indicate that freshwater fish can utilize vitamin A_1 without suffering any deleterious effects; and also that vitamin A_1 cannot be converted by them into vitamin A_2 to any appreciable extent, if at all.

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Reduction of Chloromycetin by a Cell-free Bacterial Extract and its Relation to Nitrite Reduction

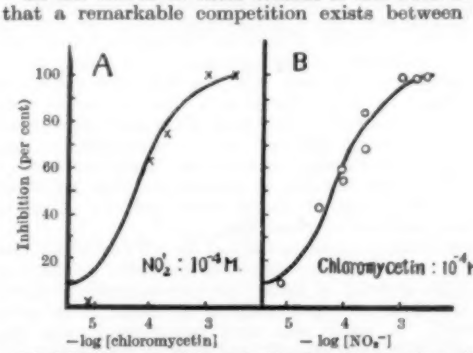
Smith and Worrel[1] reported that the nitro-group of chloromycetin is reduced to an amino-group by the action of intact cells of certain bacteria. Recently, we have been able to achieve enzymic reduction of the nitro-group of the antibiotic by a cell-free extract from *Streptococcus hæmolyticus*. Further investigation with this preparation has provided strong evidence suggesting that the enzyme system responsible for this reduction may be identical with the nitrite reductase system first discovered by Yamagata[2] in an autolysate of *Pseudomonas aeruginosa*. The present communication gives a brief report on these investigations.

Washed cells of *Str. hæmolyticus* grown for 24 hr. on a peptone–bouillon–agar medium containing 0·05 per cent sodium nitrite were dried *in vacuo* over phosphorus pentoxide. If the drying is carried out rapidly to completion, the cells are only ruptured by this simple treatment. The dried cells were then resuspended in 0·9 per cent saline and centrifuged. The clear cell-free supernatant thus obtained was used as the enzyme solution. The reduction of chloromycetin was followed by determining the formation of the corresponding amine by the method of Smith and Worrel[1]. Instead of N-[1-naphthyl]-ethylene diamine, which they used as coupling reagent, we used α-naphthylamine in our experiments. The reaction mixture consisted of 1 ml. each of the enzyme solution (corresponding to 3 mgm. of the dried cells), 0·04 *M* sodium formate, 0·2 *M* phosphate buffer of *p*H 7·2, chloromycetin at suitable concentration, and distilled water (or inhibitor solution). Incubations were carried out anaerobically at 36° using Thunberg tubes.

Under these experimental conditions, 12 per cent of the chloromycetin (4×10^{-4} *M*) was reduced in 2 hr. In an experiment with a larger amount of the extract, all the antibiotic supplied could be accounted for in terms of the amino-derivative after 24 hours incubation.

In addition, the presence of a nitrite reductase system analogous to that reported by Yamagata[2] has been confirmed in the same preparation. To study this system the same experimental conditions as those used in the reduction of chloromycetin were adopted. The activity was estimated by determining the disappearance of nitrite colorimetrically with the Griess–Ilosvay reagent.

In the course of these studies it has been noted that a remarkable competition exists between the



(*A*) Inhibition of nitrite reduction by chloromycetin; (*B*) inhibition of chloromycetin reduction by nitrite

two reduction processes. The accompanying graphs illustrate the results of a quantitative experiment on this competition. It will be seen that the reduction of nitrite (10^{-4} *M*) and that of chloromycetin (10^{-4} *M*) are completely inhibited by 10^{-3} *M* of chloromycetin and nitrite respectively. Further, a clear parallelism has been found between the actions of several inhibitors upon the two processes. Some of these results are as follows:

Inhibitor	Concentration (*M*)	Per cent inhibition of the reduction	
		of nitrite	of chloromycetin
Potassium cyanide	10^{-4}	55	45
Sodium fluoride	10^{-2}	0	3
Monoiodoacetate	2×10^{-3}	6	13
Copper sulphate	10^{-2}	60	50
Aerobic conditions	—	30	37

These facts seem to indicate the identity of the enzyme systems concerned in the two reduction processes.

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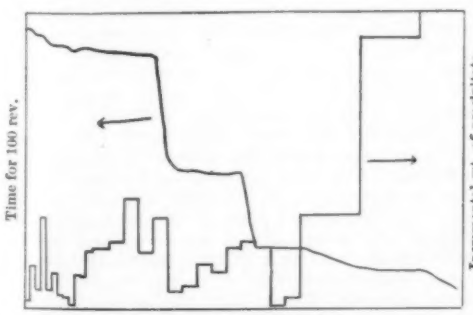
Viscometric Titration

While working with coal tar resins, which consist of an unknown number of high-molecular weight compounds, it occurred to us that viscometric titration might provide a means of assessing the number of different groups of compounds present, grouping on a molecular-weight basis. This method has been used, and, with information from other sources such as chromatography, some indication of the complexity of the materials has been obtained.

It is well known that viscometric titration can be used in precipitating a single high-molecular solute for indicating the amount of precipitant necessary for bigger-scale isolations. In the cellulose field, Kümickel[1] has used this technique. The addition of a precipitant to a solution of cellulose derivative leads to a steadily decreasing viscosity until nearly all the cellulose is precipitated, and then the viscosity rapidly decreases. We have extended this method to solutions with several solutes and have found that a stepwise curve is obtained.



Fractional titrations with tar resin solutions have been obtained with a Stormer viscometer, the sample being filtered between each addition of precipitant. The accompanying graph refers to a mixture of α- and β-Schardringer dextrins and sucrose in solution; and the incremental weight yields of precipitates are also indicated. In this case the sucrose was precipitated in a non-filterable form.

At present this method is entirely empirical and the technique is laborious, but recently Edwards[2] has described an apparatus for tachometric titration which, if modified to include filtration, could be of use in this connexion, or alternatively any continuous-reading viscometer coupled with filtration would be convenient.

The dextrins were kindly supplied by Dr. P. W. Kent, of the Department of Chemistry, University of Birmingham.

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Paper Chromatography of Pyridine Derivatives

We wish to describe briefly a convenient paper chromatographic separation and identification of pyridine derivatives in use in this laboratory for some time which employs a modification of the well-known König colour-reaction[1]. Leifer *et al.*[2] have recently described the paper chromatography of nicotinic acid and nicotinamide, but the more involved microbiological method was used for defining the spots. In this laboratory the solvent used for the development of the compounds listed in the accompanying table is *n*-butyl alcohol saturated with 1·5 *N* ammonia. After evaporation of the solvent at room temperature, the dry paper is placed for fifteen minutes in a closed glass cylinder containing a few crystals of cyanogen bromide. The vapour pressure of this substance is high enough to provide a sufficient concentration for the first phase of the König reaction. The paper is then sprayed with a 0·25 per cent solution of benzidine in 1 : 1 ethanol–water. Amounts down to 5 γ can be detected easily. It should be pointed out that although nicotinic acid and *iso*-nicotinic acid cannot be distinguished on the basis of R_F values, they can be distinguished by distinctive differences in colour. This technique should be generally applicable to all non-volatile pyridine derivatives giving a positive König colour-reaction.

	R_F value	Colour
Nicotinic acid	0·24	Red violet
iso-Nicotinic acid	0·25	Grey lavender
Nicotinamide	0·65	Red violet
Diethylnicotinamide ('Coramine')	0·84	Violet

A modification of this method has been employed in the paper chromatography of the antihistaminic, N,N-dimethyl-N′-benzyl-N″-(α-pyridyl)-ethylenediamine ('Pyribenzamine'). The reaction product of this substance with cyanogen bromide fluoresces under ultra-violet light, although no colour is obtained on addition of an aromatic amine. Mr. Mizzoni, of this laboratory, was the first to make this observation[3].

To detect the position of this antihistaminic, the dried paper, after exposure to cyanogen bromide, is observed in ultra-violet light. Spots containing 10 γ can be readily detected. The R_F value with 0·1 *N* ammonia saturated with *n*-amyl alcohol as solvent is 0·72, and with 1 per cent pyridine in water saturated with benzyl alcohol it is 0·30.

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History of Chromatography

We have been very interested to see the letter by Weil and Williams[1] and their remarks on the value of Day's work on chromatography in columns of powdered limestone and fuller's earth, and on Engler's and Albrecht's elaboration of his results, which are certainly cogent. For a complete picture of the history of chromatography, however, it is important to point out that even this is not the full story, and there is a still earlier work in which column chromatography was employed.

In connexion with the work of our Laboratory on the chromatographic analysis of raffinose and other sugars[2], we have delved deeply into the early literature, with very interesting and useful results. We have, of course, been chiefly interested in paper chromatography, and, as is fairly well known, the original ideas for this are to be found in a paper by Schönbein[3] in 1861 on the separation of substances adsorbed on filter paper, followed by the very numerous researches in this field by his pupil Goppelsroeder[4] between 1861 and 1906, of which a summary will be found in his books of 1906 and later years[5]. He records preliminary tests (1861) of kieselguhr, sand, earths, etc., for adsorbents as being without useful results. His work was thereafter all carried out on strips of filter paper or textile materials, and he investigated a most extensive range of substances, including petroleum products and plant pigments. This work was well known in its time, for example, to such chemists as E. Fischer[6].

An interesting turning point in ideas on chromatography will, however, be found in a paper by L. Reed[7] in 1893, which has been overlooked altogether until quite recently. In this paper, Reed starts with a number of tests on the lines of Goppelsroeder's methods for the separation of various substances on filter paper, cloth, etc.; at the end of this paper, however, he makes the following remarks: "With regard to the employment of porous media other than filter paper, I have obtained satisfactory results, both with the mixture of potassic chromate and eosin, and with that of ferric chloride and copper sulphate, by using tubes containing powdered kaolin lightly rammed down, upon the top of which the solution was placed and allowed to soak downwards. I had hoped that this method of separation, or some modification of it, might have proved available for the separation of alkaloids from organic matters of different nature, with a view to their subsequent identification, but have hitherto been very partially successful in this direction."

It is clear from this that, at least to Reed, the ideas of capillary analysis suggested methods of separation in columns of powdered materials. He anticipates Day's work by four years and his findings must have been well known, since such chemists as Meldola, H. B. Baker and F. Stanley Kipping presented papers at the same meeting. We may therefore assume that, if the connexion between work on paper suggested work on columns to Reed, it was also a stimulating idea to later workers, and it must be supposed with reasonable certainty that this work was known to Day and perhaps also to Tswett, who, though a botanist, certainly had strong chemical interests. Reed's work is briefly mentioned by Goppelsroeder in regard only to the tests on paper; but his test with a column has been entirely overlooked both by Goppelsroeder and by all the later well-known writers on column and paper chromatography. It was, however, also discovered recently by Feigl, and is mentioned in his book on the "Chemistry of Specific, Selective and Sensitive Reactions"[8], and again in a recent article by him[9]. The real start of chromatographic analysis must therefore rest with Goppelsroeder, and the credit for the first (published) idea of work on columns be given to Reed. The importance of Tswett's work is then to be found in his discovery of the development of a chromatogram with pure solvent.

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William Higgins and John Dalton

In a recent review[1] of Prof. Soddy's book, "The Story of Atomic Energy" (London, 1949), Prof. Paneth directs attention to a part of the book in which "credit is given not to John Dalton but to William Higgins for being the first to proclaim the modern atomic theory, a statement supported by detailed references to two books[2] of this 'almost forgotten investigator' ". Prof. Paneth adds that "Dalton's astonishing limitations as a scientific thinker—as revealed in his notes about the constitution of gases and his stubborn fight against Gay-Lussac's results which was the consequence—seem to justify the more modest position allotted to him here. In any event, writers of chemical text-books will now have to re-examine this question." Prof. Soddy had "hoped that future historians of the atomic theory may give more attention to these two books of William Higgins. They certainly serve to establish the writer's view that, once Lavoisier's Theory of Combustion was accepted, the next natural step was the modern atomic theory, and that Higgins definitely took this step 15 years before Dalton." The "usually trustworthy historian Ernst von Meyer" had given a "completely false" judgment, and it is to be doubted

"whether any of those who supported the claims of Dalton over those of Higgins . . . were even competent to understand, let alone pronounce so pontifically upon, the reasoning the latter advanced in support of his conclusions . . . Some account therefore of the actual work of this almost forgotten investigator seems called for to redress, and possibly reverse, the biassed verdict of the last century."

Since I have fairly recently published[1] a detailed study of the question, of which neither Prof. Soddy nor Prof. Paneth can be aware, and since many of my conclusions are quite at variance with theirs, it seems necessary for me to deal with the matter. I may preface my remarks by saying that, like Prof. Soddy, I have read both the books by Higgins. Since my study is so easily accessible, it is unnecessary to burden the crowded page of *Nature* by a repetition of it, but the following points may be summarized.

(1) That Higgins recognized the law of multiple proportions has often been stated and was emphasized in my paper. His ideas about combining volumes[2] are also, as Prof. Soddy says, interesting. Prof. Soddy, unfortunately, ignores the share of William's uncle, Bryan Higgins, in these speculations, which I dealt with in some detail.

(2) The most striking difference between the atomic theories of Higgins and Dalton is the neglect by the former of the weights of the atoms. This was the central point of Dalton's theory and entitles him to the place which historians of chemistry have always given him. An atomic theory was in existence long before William Higgins and was applied in many ways to the explanation of physical and chemical phenomena, and even Newton seems to suggest that atoms differ in weight. So far as I know, Dalton was the first to find the relative weights of the atoms, with some degree of success. I have corrected my lamented friend, Prof. A. N. Meldrum, by pointing out that only once in his book does Higgins suggest that the atoms of different elements differ in weight, and he nowhere implies that this is a matter of importance.

(3) I have given reasons for supposing, with the "Dictionary of National Biography", that Higgins's book[2] published in 1814, long after Dalton's theory had been developed and accepted, was "an unworthy attack on Dalton". No chemist who had read his book of 1789 was able to cull from it any such theory as that proposed by Dalton (which was arrived at in quite a different way). Thomas Thomson definitely says he did not. A syllabus of lectures given by Higgins in 1802 makes no mention of an atomic theory. It was necessary for Higgins to belittle Dalton if he hoped to take his place, and he did not shrink from doing it.

(4) Prof. Soddy, after saying that Higgins in 1789 used the symbols S, O and N for the atoms of sulphur, oxygen and nitrogen, adds: "and it may have been the guilty knowledge of this which made Dalton hostile to the substitution of his own cumbrous special symbols by the simple universal system of Berzelius". Higgins actually uses the symbol P for nitrogen, and *a*, *b*, *c*, etc., for oxygen. The letter P obviously stands for 'phlogisticated air' (nitrogen) and S for sulphur. Prof. Soddy is, I think, the first to direct attention to this use of letter symbols by Higgins, which had escaped me in a note which I published on this subject[4]. I gave reasons in my paper in 1939 for supposing that Dalton never read the book by Higgins. Prof. Soddy produces no evidence that he did, and until he does no one who has studied Dalton's character will feel willing to accept a charge of dishonesty against him.

(5) Davy, whose views are mentioned by Prof. Soddy, was the first chemist of eminence to recognize Dalton's genius. He invited Dalton to lecture to the Royal Institution in 1803–4 and 1809–10 before much was known of him or his theory. Davy also visited Dublin in 1810 and 1811, where he was made very welcome and paid a very large fee for his courses of lectures. He must have had an account of Higgins's work from its author and, since he was a man of independent mind, Davy was no doubt impressed. Davy's pronouncements on the origin of the atomic theory made at different times will repay study.

(6) Dalton's views on the constitution of gases are not confined to "notes". They are published in his "New System of Chemical Philosophy" and are essential parts of his theory. His circular symbols, which he was as unwilling to abandon as Sir J. J. Thomson was his name "corpuscle", represented what Dalton thought the atoms looked like and hence were, to his mind, better than letters of the alphabet. In the same book Dalton pointed out the difficulty in the assumption (which was never made by Gay-Lussac) that equal volumes of gases contain equal numbers of atoms. This difficulty was resolved by Avogadro, but since Avogadro's paper was neglected by chemists, great and small, for more than fifty years, it is perhaps unfair to refer to Dalton's "astonishing limitations as a scientific thinker", and more to the point to realize that he had thought out this fundamental matter so early. I am aware that Prof. Paneth was probably also thinking of Dalton's experiments on the combining volumes of oxygen and hydrogen.

(7) It is not clear what Prof. Soddy means by saying that Higgins and Dalton are responsible for "the modern atomic theory", since Prof. Meldrum in several papers (references to which I gave) took pains to show that nothing could be more unlike than their theories and the atomic theory as taught in, say, 1860, let alone anything more modern. It is also necessary to direct attention to the fact that "Lavoisier's Theory of Combustion" is not what many writers think it is, but was intimately connected with the theory that heat and light are imponderable elements, that is, material, as was also believed by Dalton[5].

I may add, in conclusion, that Prof. T. S. Wheeler, of University College, Dublin, is engaged in a detailed study of William Higgins, which will be published in due course. This will correct some statements about Higgins which have been current and will clear up many points of detail.

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[1] *Nature*, **166**, 799 (1950).

[2] (i) "A Comparative View of the Phlogistic and Antiphlogistic Theories" (1789 and 1791). The fact that two editions of this book, which is now very scarce, were published, suggests that it must have been fairly well known. It is essentially an argument in favour of Lavoisier's new theory, which is very notable for its date, and the atomic theory, which was largely based on that previously published by Bryan Higgins, was a secondary interest in it; the assumption that the particles of different gases are at different distances from one another (not emphasized by Prof. Soddy) was taken over by Higgins from Austin (1788). (ii) "Experimental Observations on the Atomic Theory and Electrical Phenomena" (1814)—Higgins still maintains his idea of the equal weights of atoms even in this book.

[3] Partington, "The Origins of the Atomic Theory", *Annals of Science*, **4**, 245 (1939); "A Short History of Chemistry", 166 (1948).

[4] *Chemistry and Industry*, **55**, 759 (1936).

[5] Partington and McKie, "Historical Studies on the Phlogiston Theory", *Annals of Science*, **2**, 361 (1937); **3**, 1, 337 (1938); **4**, 113 (1939).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Saturday, January 20

BRITISH MYCOLOGICAL SOCIETY (in the Department of Biology, Chelsea Polytechnic, Manresa Road, London, S.W.3), at 11 a.m.—Scientific Papers.

Monday, January 22

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. J. N. Jennings: "The Origin of the Broads".

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. J. Z. Young, F.R.S.: "Biological Relativity".

INSTITUTE OF METALS, LONDON SECTION (joint meeting with the SOCIETY OF CHEMICAL INDUSTRY, at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6 p.m.—Dr. F. P. Bowden: "Friction and Lubrication of Solids".

INSTITUTION OF THE RUBBER INDUSTRY, MANCHESTER SECTION (joint meeting with the MANCHESTER AND DISTRICT BRANCH of the INSTITUTE OF PHYSICS, at the Engineers' Club, Albert Square, Manchester), at 6.15 p.m.—Mr. E. F. Powell: "The Application of Physical Techniques in the Rubber Industry".

Tuesday, January 23

ASLIB (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—"Impressions of American Special Libraries and Information Services" (Speakers: Dr. D. J. Urquhart, Miss Barbara Kyle and Mr. Howard Drake).

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Discussion on "The Training of Craftsmen" (to be introduced by Mr. J. Loxham).

UNIVERSITY OF LONDON (in the Electrical Engineering Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. H. E. M. Barlow: "Field Guides at High Temperatures".* (Further Lectures on January 26, 30 and February 2.)

PLASTICS INSTITUTE, LONDON AND DISTRICT SECTION (at the Waldorf Hotel, Aldwych, London, W.C.2), at 6.30 p.m.—Mr. A. Beecham: "History and Development of Thermosetting Materials in the Rayon Industry".

Wednesday, January 24

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. W. P. K. Findlay: "Dry-Rot in Timber".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Dr. M. Grünhut: "Statistics in Criminology".

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY, CHEMICAL SECTION (at the Portico Library, Mosley Street, Manchester), at 5.45 p.m.—Dr. R. E. Fairbairn: "Chemical Literature To-day".

BRITISH INSTITUTION OF RADIO ENGINEERS, WEST MIDLANDS SECTION (at the Technical College, Wulfruna Street, Wolverhampton), at 7 p.m.—Mr. C. Naylor-Strong: "The Mechanics of Hearing".

Thursday, January 25

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. A. L. Cullen: "Wireless Waves".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. G. G. Hall and Sir John Lennard-Jones, F.R.S.: "The Molecular-Orbital Theory of Chemical Valency (7) Molecular Structure in terms of Equivalent Orbitals".

PHYSICAL SOCIETY (in the Main Lecture Theatre, Huxley Building, Imperial College of Science and Technology, Exhibition Road, London, S.W.7), at 5.30 p.m.—Symposium on "The Electron Theory of Metals".

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (joint meeting with the SOUTH-WESTERN SECTION, at the Technical College, Tavistock Road, Plymouth), at 5.30 p.m.—Mr. Brynmor Thomas: "The Chemist in Agriculture".*

INSTITUTE OF METALS, BIRMINGHAM SECTION (at the James Watt Memorial Institute, Great Charles Street, Birmingham), at 6.30 p.m.—Mr. D. J. C. Brandt: "The Use of Oxygen in Steelmaking".

ROYAL STATISTICAL SOCIETY, SHEFFIELD GROUP of the INDUSTRIAL APPLICATIONS SECTION (in the Cavendish Room, Grand Hotel, Sheffield), at 6.30 p.m.—Mr. D. J. Desmond: "Statistics and Time Study".

ROYAL GEOGRAPHICAL SOCIETY (joint meeting with the ROYAL PHOTOGRAPHIC SOCIETY and the ROYAL INSTITUTE OF CHARTERED SURVEYORS, at the Royal Photographic Society, 16 Prince's Gate, London, S.W.7), at 7 p.m.—Mr. P. G. Mott: "The Practical Application of Photogrammetric Surveying".

Friday, January 26

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, MICROCHEMISTRY GROUP (at the Sir John Cass College, Jewry Street, London, E.C.3), at 4 p.m.—Sixth Annual General Meeting; at 6 p.m. Symposium on "Radiochemical Techniques in Microchemistry".

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion on "Water Circulation in the Oceans".

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Mining Institute, Newcastle-upon-Tyne), at 6.15 p.m.—Prof. L. C. Burrill and Mr. A. G. Boggis: "Electronics in Naval Architecture".

PLASTICS INSTITUTE (at the Engineers' Club, Albert Square, Manchester), at 6.45 p.m.—Mr. J. S. Turnbull: "Lost Wax Precision Casting".

TELEVISION SOCIETY (at the Cinema Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2), at 7 p.m.—Discussion on "Colour Television" (to be opened by Mr. T. M. C. Lance).

Saturday, January 27

BIOCHEMICAL SOCIETY (at the Postgraduate Medical School, Ducane Road, London, W.12), at 10.30 a.m.—Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT CHEMIST IN THE FUELS AND LUBRICANTS SECTION of the Central Laboratory, Chiswick—The Staff Officer (F/EV.157), London Transport Executive, 55 Broadway, London, S.W.1 (January 27).

ASSISTANT PHYSICIST (with an honours degree in physics and previous experience in hospital physics) at the Joint Radiotherapy Centre—The Secretary, Northern Group Hospital Management Committee, Royal Northern Hospital, Holloway, London, N.7 (January 27).

SENIOR ASSISTANT IN PHYSICS—The Registrar, Nottingham and District Technical College, Shakespeare Street, Nottingham (January 27).

TEACHER OF BIOLOGY (zoology and some botany to Intermediate B.Sc. standard), and a TEACHER OF BIOLOGY and CHEMISTRY (to at least Intermediate B.Sc. standard)—The Principal, Norwood Technical College, Knight's Hill, London, S.E.27 (January 27).

TECHNICAL LIBRARIAN at the Central Research Establishment at Stoke Orchard, near Cheltenham—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/283 (January 27).

PRINCIPAL SCIENTIFIC OFFICERS (2) in the Research and Development Branch of the Department of Supply, South Australia, to be responsible under the direction of a Superintendent for the planning and supervision of the activities of a group undertaking research and development for a new defence equipment in the field of radio, radar and allied techniques—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (January 29).

SENIOR SCIENTIFIC OFFICERS (4) in the Research and Development Branch of the Department of Supply, South Australia, to be responsible to a Principal Scientific Officer for the detailed direction of the work of a team engaged on research and development for new defence equipment in the field of radio, radar and allied techniques—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (January 29).

LECTURER (with a degree in physics and/or mathematics) IN MATHEMATICS AND PHYSICS, and a LECTURER (with a good engineering degree, or equivalent qualification, and adequate industrial experience) IN MECHANICAL ENGINEERING, at the Glamorgan Technical College, Treforest—The Director of Education, County Hall, Cardiff (January 31).

LECTURER IN PHYSIOLOGY—The Registrar, The University, Leeds 2 (January 31).

PHYSICIST, a HYDRAULICS OFFICER, and a PHYSICAL CHEMIST, in the Punjab Public Works Department Irrigation Branch—The Office of the High Commissioner for Pakistan, 35 Lowndes Square, London, S.W.1 (January 31).

CHAIR OF PSYCHOLOGY at the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Rondebosch, February 24).

LECTURER IN BOTANY (with special qualifications in plant physiology or experimental botany) at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (February 28).

LECTURER IN THE DEPARTMENT OF LAND SURVEYING of the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Rondebosch, February 28).

ANALYTICAL CHEMIST/WATER SPECIALIST (with a good degree and experience in water analysis from the industrial and public health aspects)—The Divisional Establishment Officer, National Coal Board, Himley Hall, Dudley, Worcs.

BIOLOGIST, an ASSOCIATE BIOLOGIST, an ASSISTANT BIOLOGIST, and a JUNIOR BIOLOGIST, to form part of a team carrying out research on the various groundfishes—The Director, Newfoundland Biological Station of the Fisheries Research Board of Canada, St. John's, Newfoundland, Canada.

CHEMIST (with a first- or good second-class honours degree in chemistry and at least two years postgraduate research experience) with the Colonial Insecticides Research Unit now operating in Tanganyika—The Under-Secretary of State (Research Department), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.

METEOROLOGICAL ASSISTANTS by the Government of Northern Rhodesia—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.27295.E.

PHYSICISTS and ELECTRONICS ENGINEERS (Experimental Officer grade) in Ministry of Supply research and development establishments mainly in the south of England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.360/50A.

SENIOR ASSISTANT IN MATHEMATICS—The Registrar, Portsmouth Municipal College, Portsmouth.

SENIOR METEOROLOGICAL OFFICER and METEOROLOGICAL OFFICERS (3) in the Civil Aviation Department, Northern Rhodesia—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27118/14.

TECHNICAL ABSTRACTOR (preferably with a degree in engineering, or its equivalent, and a sound knowledge of French and/or German)—The Director, Motor Industry Research Association, Great West Road, Brentford, Middx.

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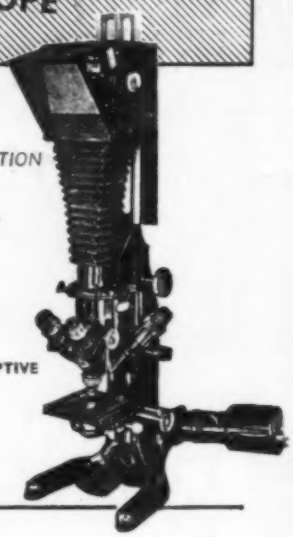

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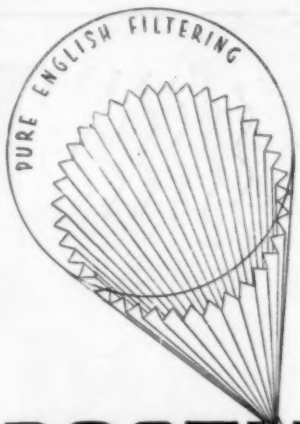

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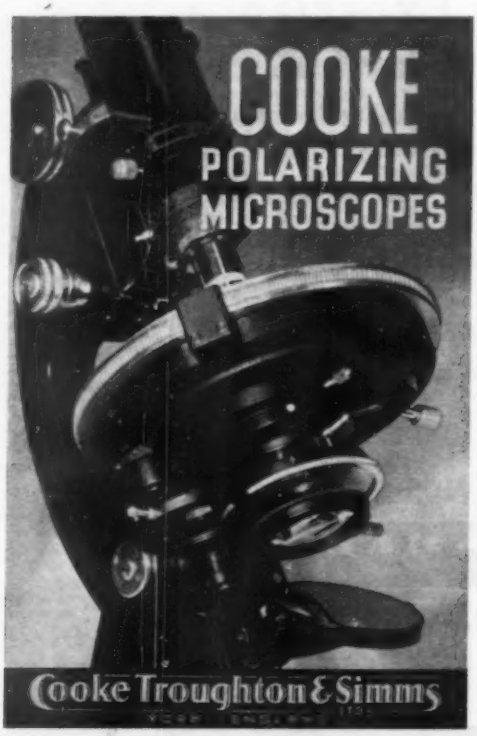

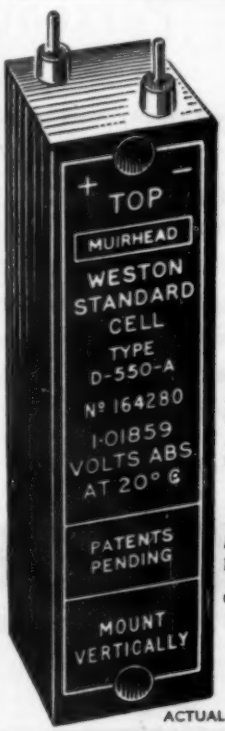

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